Weight Engineering Analytical Tool Development
(PBA D802)

ASSET Electrical Power Generation & Distribution System Critical Design Review

[redacted]

CDR Agenda

12:30 PM	Introduction	James Lee
12:45 PM	Architecture	George Gregorios
1:05 PM	Loads	George Gregorios
1:25 PM	Generation	Ken Perez
1:50 PM	Main Power Feeders	Bob Bond
2:10 PM	Power Panels	Glenn Parkan
2:20 PM	Break	
2:30 PM	Reliability	Paul Covert
2:50 PM	IRAP Interface	Dave Twigg
3:10 PM	Maintainability	Paul Covert
3:20 PM	Dependability Cost	Mahyar Rahbarrad
3:40 PM	Weight Summaries	Bob Bond
3:50 PM	Around the Room	All
4:00 PM	Adjourn	

ASSET Electrical Method

Introduction

James Lee
Weight Engineering

[redacted]

CDR Goals

- Present what is in the method

- Explain how the method works

  Explain method design, screens, and data flow

- Obtain critique to improve method (Action Items)

Principal Cross-Functional Contacts

John Peters	Electrical Power Systems, Supervisor
Alan Bernier	Electrical Power Systems, LAPD Team Lead
Ed Woods	Variable Frequency Power, Skin Effect Impedance
Liet Nguyen	Power Distribution Panels, Feeder Wire Analysis
James Merrick	AC Loads & Power Conversion
David Larsen	AC Loads & Power Conversion
Mihail Ionescu	737 AC Loads
Del Silva	Cabin Systems, IFE Power Requirements
Charles Kusuda	IFE Cooling Requirements
Bob Gilbo	Integrated Drive Generator
Mahyar Rahbarrad	Dependability Cost
Paul Covert	Reliability, Maintainability
Dave Twigg	Distributed Computing
Upender Sandadi	Integrated Reliability Analysis Program
Ken Gubler	Reliability, Maintainability, & Testability

Principal Supplier Contacts

Dinesh Taneia	Smiths Industries - Leland
John Paterson	Allied Signal Aerospace
Tom Imel	Smith's Industries
Hervé Devred	Auxilec
John Diemer	Sundstrand
Franck Kolczak	ECE - Intertechinque
Nayan Surti	Lucas Aerospace
Steve Peecher	Smith's Industries - St. Louis
Michael Srebnicki	Rockwell-Collins
Robert Laing	Eurotech
Lee Trousdale	Rockwell-Collins
Paul Clemens	Smiths Industries
David Sample	Rockwell-Collins
Eddie Yue	Allied Signal Aerospace
Dave Cunningham	Sundstrand

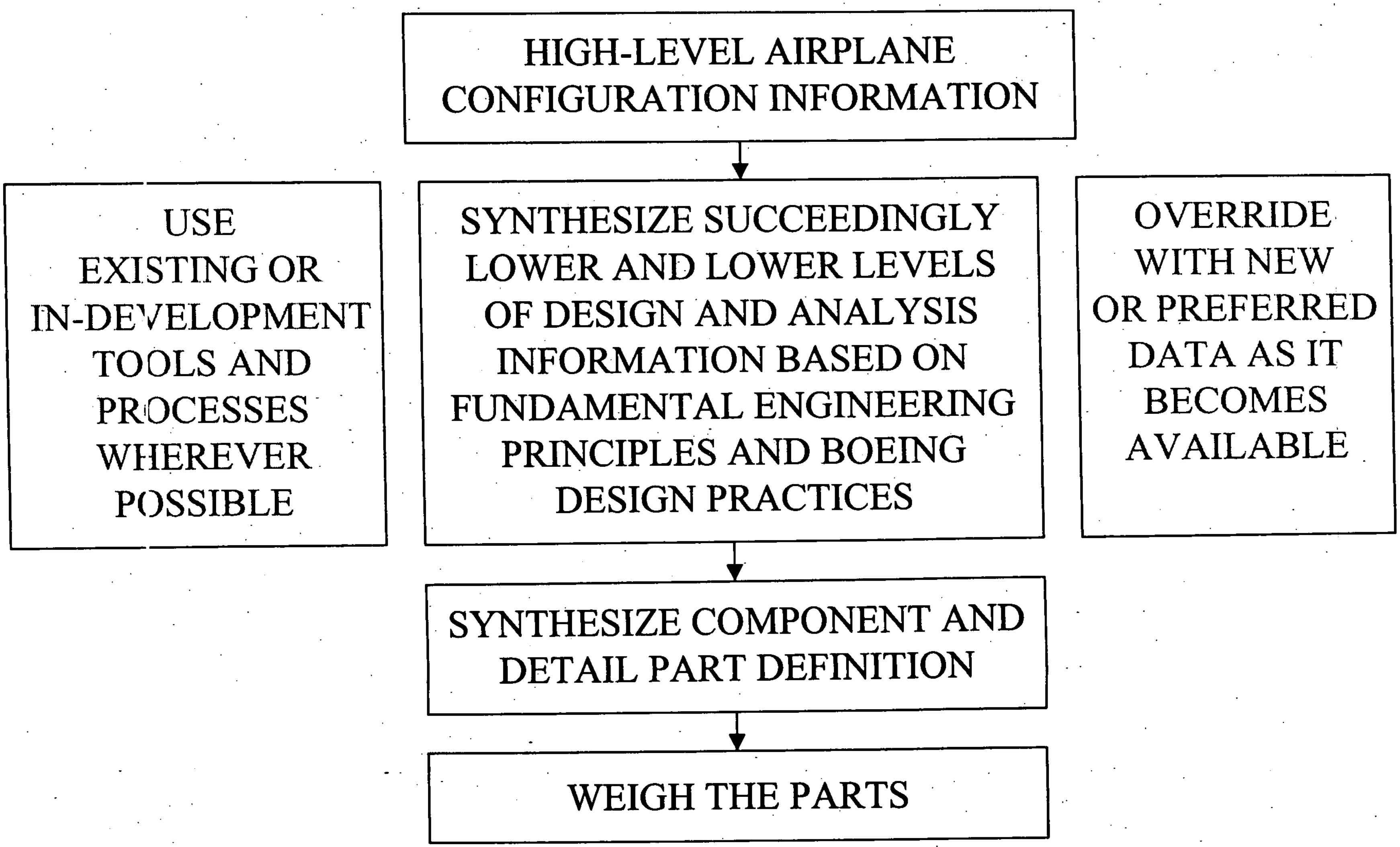
WHAT IS ASSET?

ASSET IS A SET OF ENGINEERING TOOLS THAT SYNTHESIZE AN APPROXIMATE PART-LEVEL DESIGN DEFINITION FROM A COMBINATION OF:

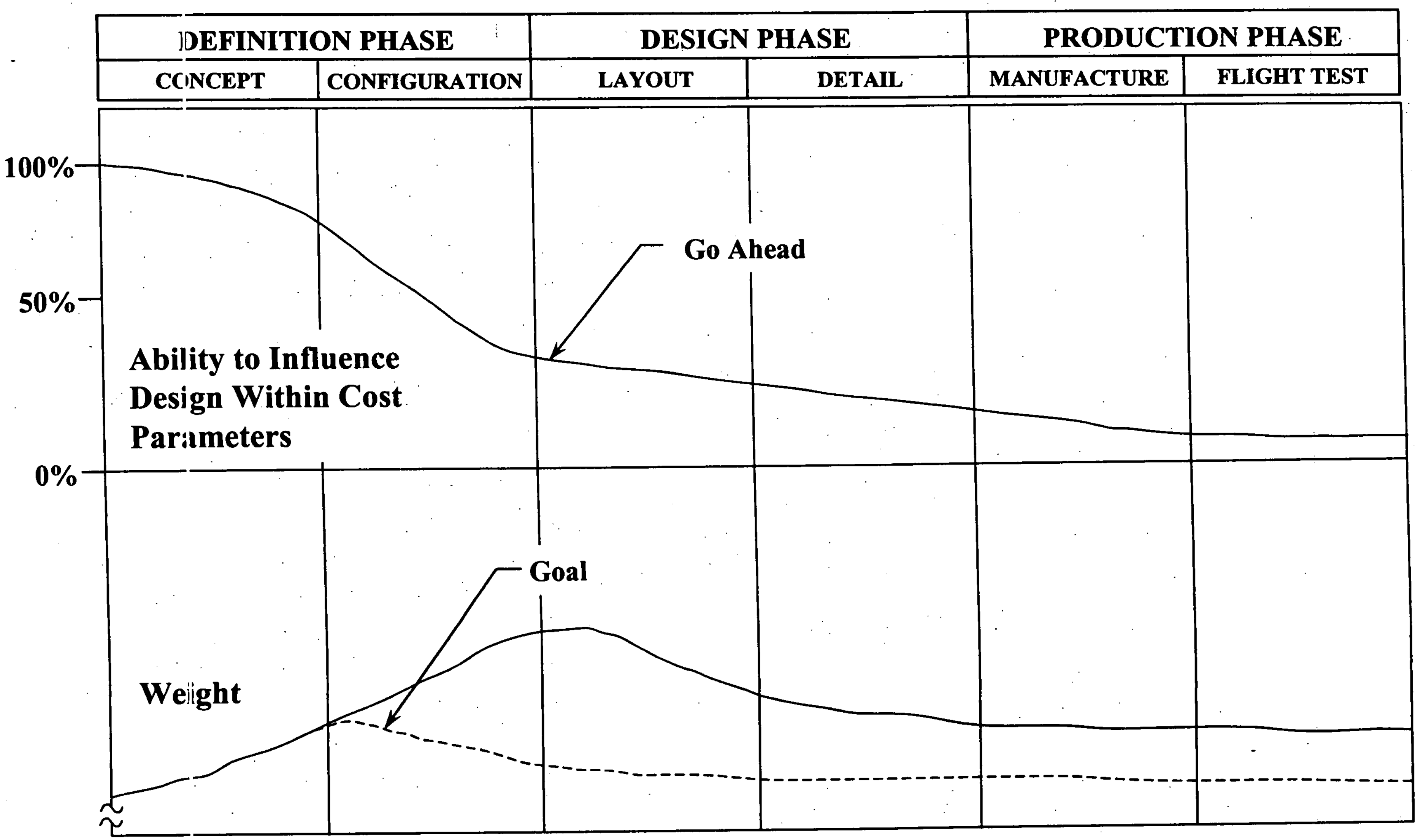
- AIRPLANE LEVEL CONFIGURATION DATA
- FUNDAMENTAL ENGINEERING THEORY
- CROSS-FUNCTIONAL DESIGN/ANALYSIS PRACTICES
- MORE DETAILED DATA, AS IT BECOMES AVAILABLE

THE SYNTHESIZED DESIGN IS THEN ASSESSED FOR WEIGHT, COST, RELIABILITY, ETC.

THE ASSET CONCEPT

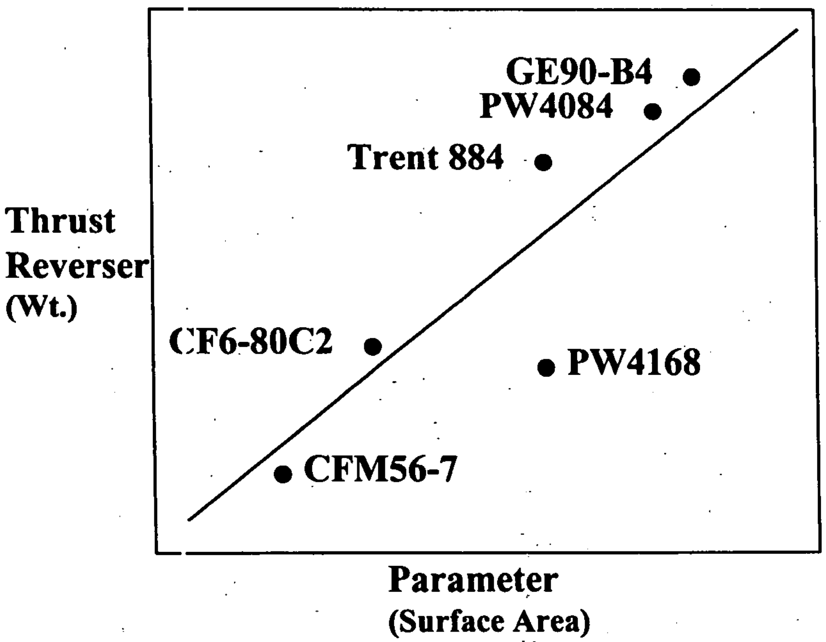


BENEFITS OF EARLY PRODUCT DEFINITION

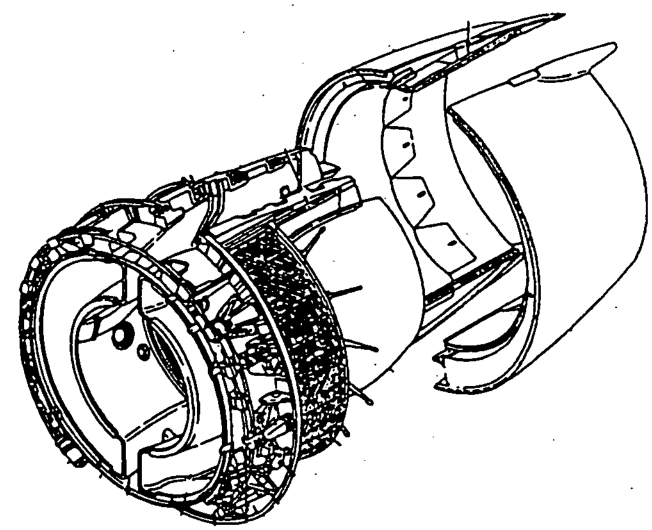


Technical Review
Parametric vs. Design-Based Weight Analysis Tools

Parametric (old method)



Design-Based (new method)

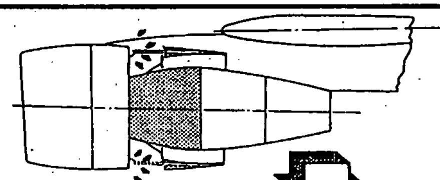


Disadvantages
- Design Definition Unknown
- Weight Control Impossible
- No Trade Capability

Advantages
- Discriminates Between Designs
- Weight Control Possible
- Has Trade Capability

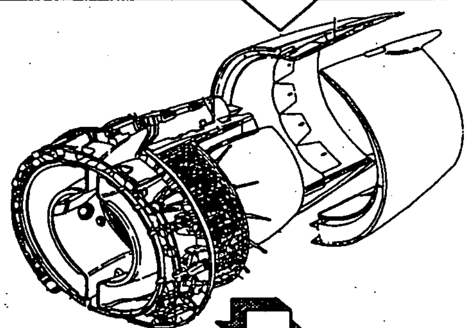
Thrust Reverser

Concept



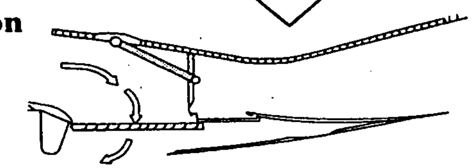
- Strut Type
- Duct Type
- Load Share
- Bypass Ratio
- Accessories Location

Conditions



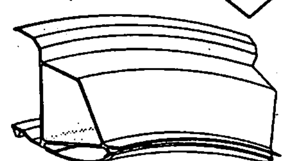
- Design Conditions
- Thrust Levels
- Acoustic Requirements
- Air Flow Rates
- Pressures
- Temperatures
- Aero Characteristics
- Deployment Rates
- External Loads

Configuration



- Lengths / Diameters
- Load Paths
- Bifurcation Angles
- Sleeve Stroke
- Duct Area
- Cascade Area
- Acoustic Lining

Sub Assembly



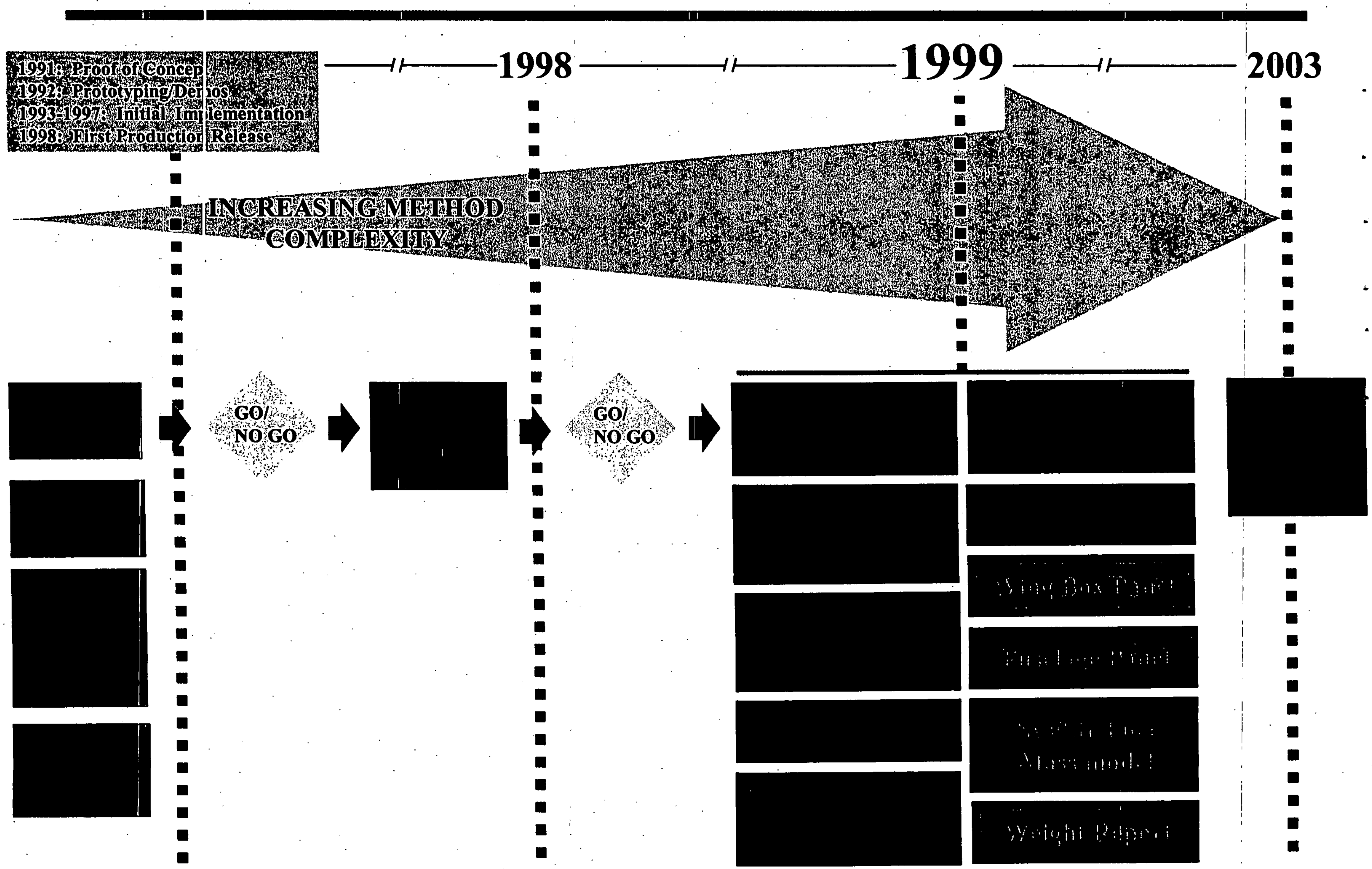
- Envelopes
- Part Arrangements
- Cutouts
- Internal Loads
- Section Properties
- Component Quantities
- Fastening

Part

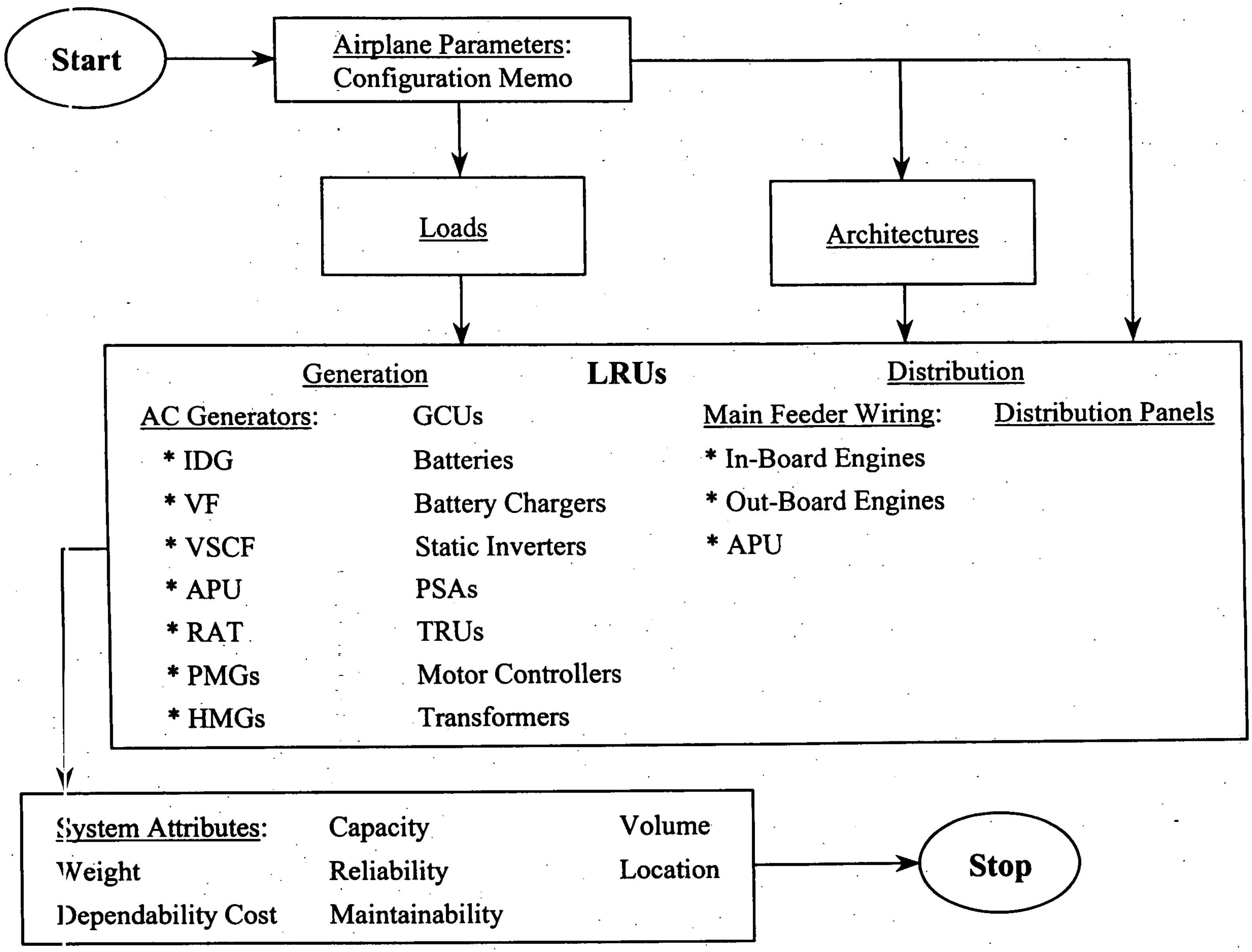
- Dimensions
- Stresses
- Material – Properties
- Manufacturing Methods
- Gages
- Weight

[redacted]

Knowledge-Based Method Development Strategy



Method Process Flow Diagram



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4:00 PM	Adjourn	

ASSET Electrical Method

System Architecture

George Gregorios
Weight Engineering

[redacted]

System Architecture - Purpose

- System Architecture along with Load Analysis , FAR and Boeing Requirements are the basis of sizing power sources.

- System Architecture will populate the system attribute table with electrical generation/conversion components to generate systems weight.

Internally Generated System Architecture

For minimum ASSET requirements, the following Electrical Power System Architecture was considered baseline:

Twin Engine, Non Fly-By-Wire: 767-200/737NG, 2- Channel, Isolated

Twin Engine, Fly-By-Wire: 777-300, 2 - Channel, Isolated

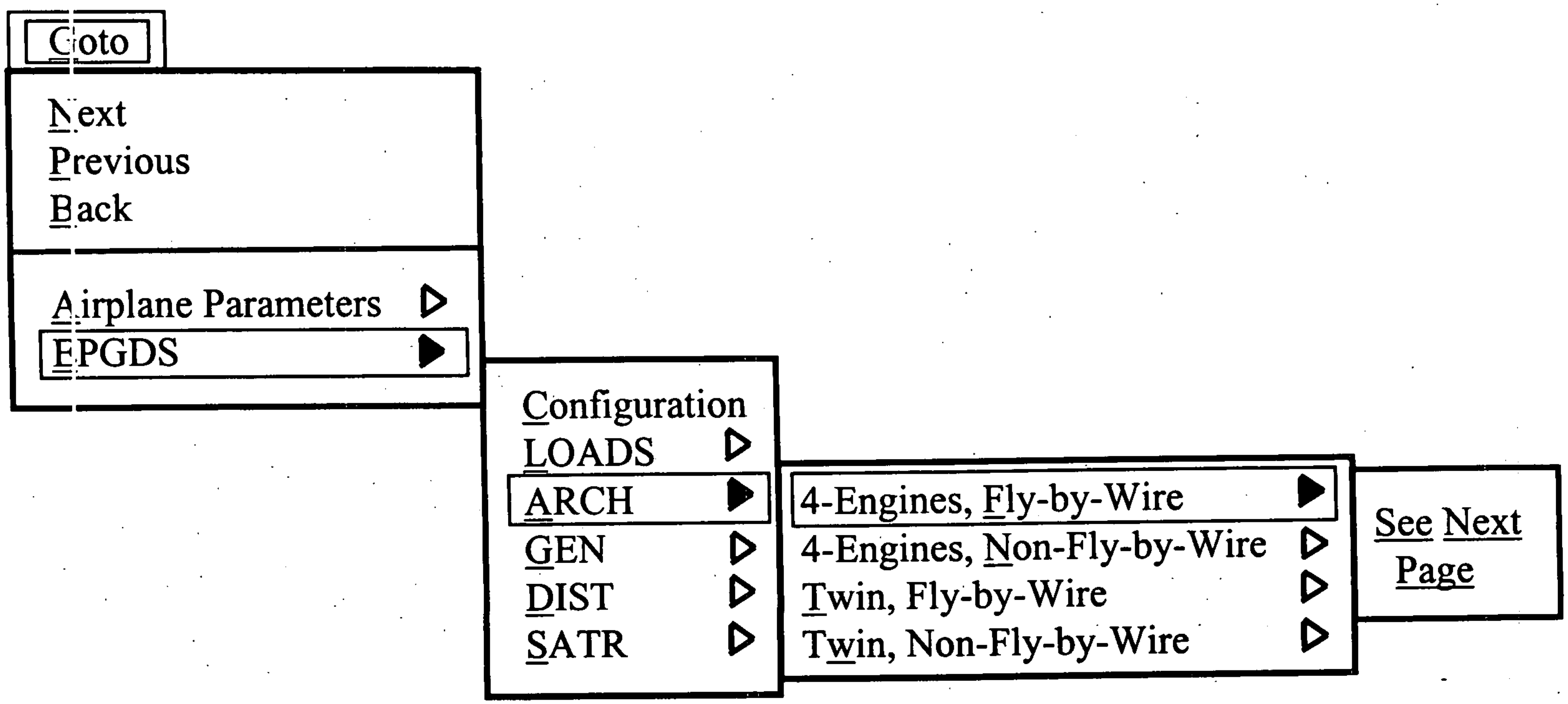
Four Engine, Non Fly-By-Wire: 747-400, 4 - Channel, Split Parallel

Four Engine, Fly-By-Wire: Large Airplane PD, 4 - Channel, Isolated

- Users can override internally generated architecture

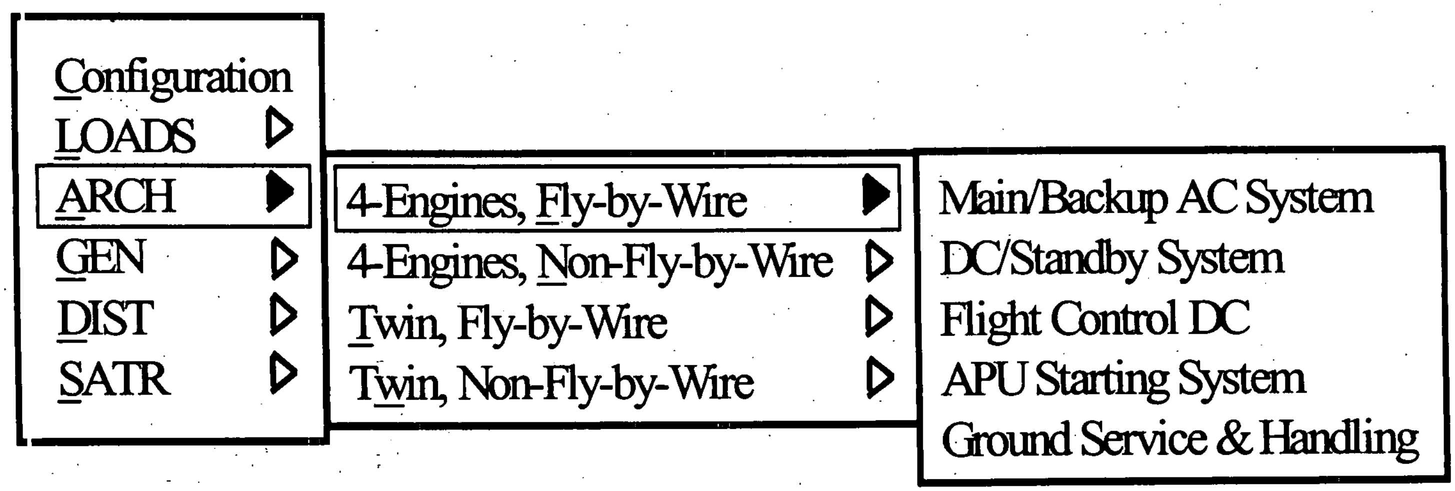
System Architecture - Screen Pull-down Menu

Pull-down menu for Architectures:



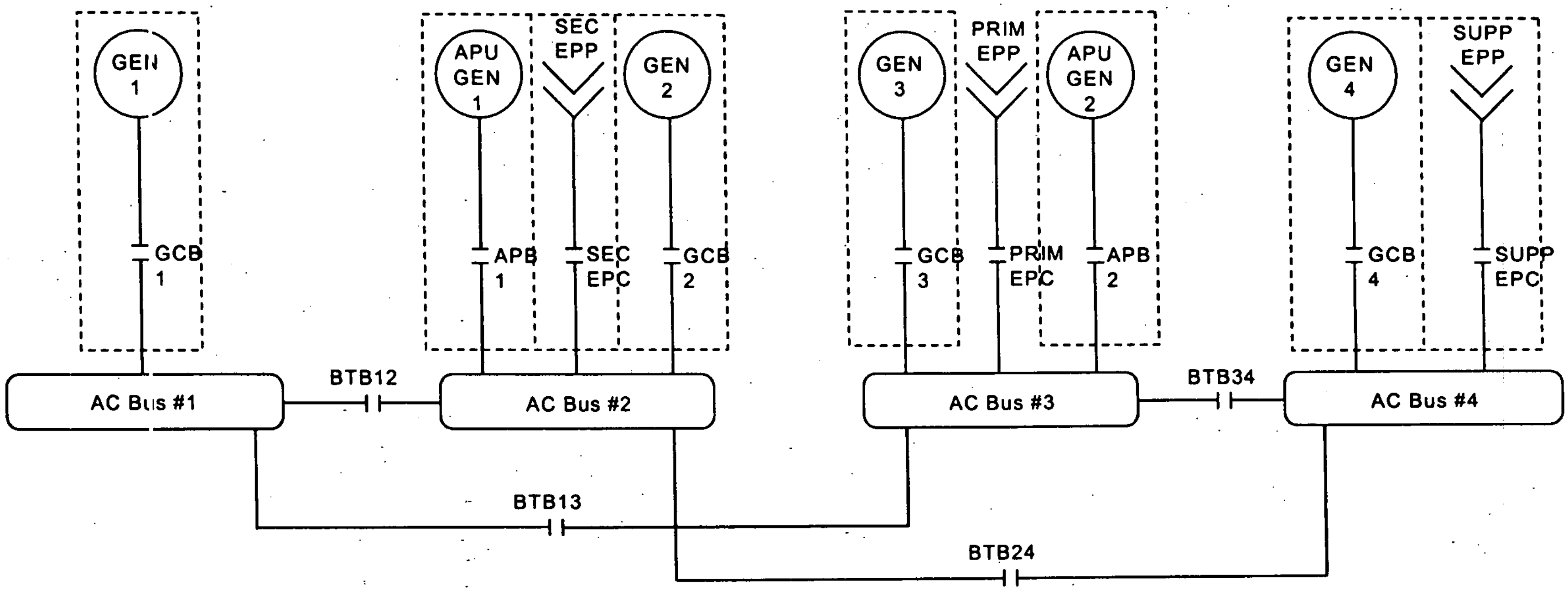
System Architecture - Screen Pull-Down Menu

Continuation of pull-down menu for Architectures:



File Run Goto Report Help

AC Main System Architecture
Four Engine, Isolated Channel, Fly-by-Wire



Legend:

GCB - Gen. Circuit Breaker
EPC - External Power Contactor
APB - Aux. Power Breaker
BTB - Bus Tie Breaker
EPP - External Power Panel

Screen Variances? ☐ False

ATA 24-21 Screen

File Run Goto Report Help

ATA Chapter 24-21, Power and Regulation

Component Attribute Summary: Comp #	Component Designation	Quantity	Unit Weight	Subtotal Weight
M24001	IDG AC Gen, INBD R	1	156.6 LB	156.6 LB
M24001	IDG AC Gen, INBD L	1	154.6 LB	154.6 LB
M24001	IDG AC Gen, OBD R	1	154.6 LB	154.6 LB
M24001	IDG AC Gen, OBD L	1	154.6 LB	154.6 LB
M24003	APU Generator R	1	67.0 LB	67.0 LB
M24003	APU Generator L	1	67.0 LB	67.0 LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB

ASSET EPGDS Method

CDR Agenda

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3:40 PM	Weight Summaries	Bob Bond
3:50 PM	Review Action Items	Reid Wakefield
4:00 PM	Adjourn	

BOEING

ASSET Electrical Method

Load Analysis

George Gregorios
Weight Engineering

[redacted]

Load Analysis - Purpose

The load analysis is the basis for sizing the electrical power system during development.

It considers the maximum configuration and is used to validate the system capacity.

- With ASSET minimum input requirements, internally generated loads is needed for power source sizing to generate electrical system generation/distribution weights.

Methodology/Assumptions

- Analysis for each power system configuration are sorted by ATA.

  For minimum input ASSET requirement, internal generated loads are calculated using a selected baseline loads (narrow body= 737-800 HAP YC003, wide body= 777-300 CAT WA504) scaled up to a given configuration or system architecture data such as number of engines, number of passengers, range/mission, number of pumps and fans.

  Steady state, worse case, end of life.

  No in-rushes or momentary loads.

- Duty cycle/utilization factor applied to intermittent loads.

Methodology/Assumptions

Main feeder losses, conversion efficiences included.

Apply 15% error/growth factor to total calculated values for power source sizing.

Users can override internally generated loads.

Example of Methods - Internally Generated AC Loads
ATA 21 Air Conditioning

Algorithm:

Wide Body

Calculated Load= 777 ECS loads x (No. of Pass. / 777 No. of Pass) x (Number of Fans / 777 Number of Fans)

Narrow Body

Calculated Load= 737NG ECS loads x (No. of Pass. / 737NG No. of Pass) x (Number of Fans / 737NG Number of Fans)

ATA 21 Major Fan Loads: Re-circulating, E/E Cooling Vent and Supply, IFE/AVOD.

Power Sources Sizing - Assumptions

FAR 25.1351 and the following Boeing requirements are used to determine the size of power sources.

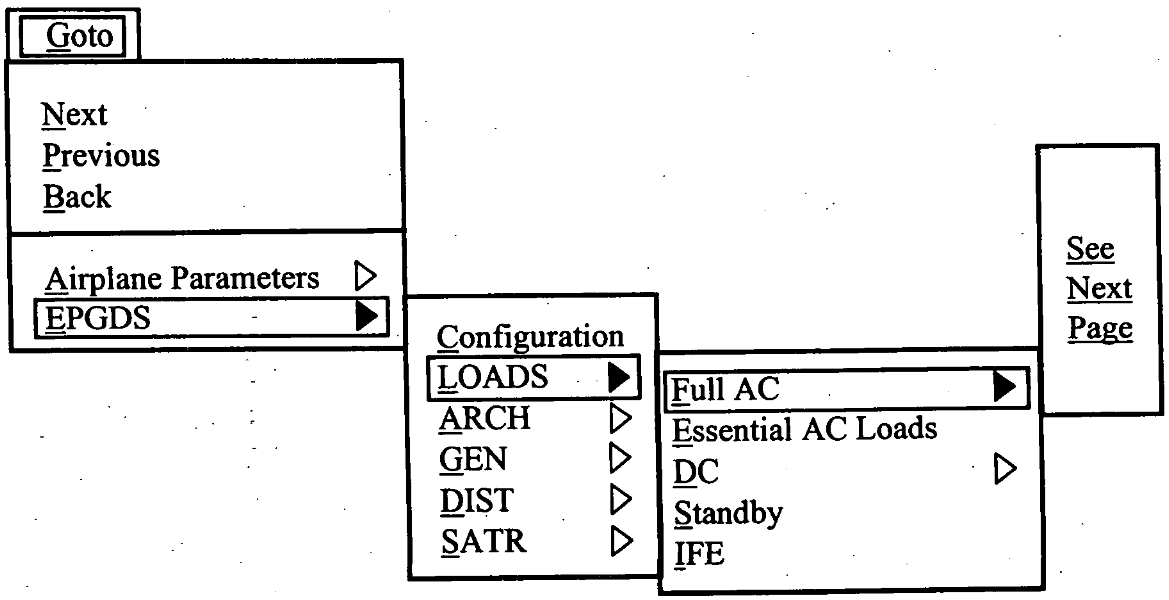
- Generators sized to support all essential loads on one generator.
  - Dispatch with one generator inoperative.
  - APU generator operate on ground only.

- Dispatch with one TRU out

Static Inverter must be capable of powering all flight critical AC loads during emergency operation.

Loads Analysis - Screen Down Menu

Screen pull-down menu for Full AC Loads:



Load Analysis - Screen Down Menu

- Full AC ▶
  - AC Electrical Load Characterization
  - AC Load Summary by Flight Phase
- Essential AC Loads
- DC ▷
- Standby
- IFE

Screen for AC Electrical Load Characterization:

File Run Goto Report   Help

AC Electrical Load Characterization

Fans	N_Fans	Narrow Body Pumps	N_NB_Pumps
Recirculation Fans	N_Recirc_Fans	Narrow Body Boost Pumps	N_NB_Boost_Pumps
EEC Vent Fans	N_EEC_Vent_Fans	Narrow Body Override Pumps	N_NB_Override_Pumps
EEC Supply Fans	N_EEC_Supply_Fans	Narrow Body Jettison Pumps	N_NB_Jettison_Pumps
TRUs	N_TRU	ACMPs	N_ACMPs
Wide Body Pumps	N_WB_Pumps	Wdw/Wndshld Heaters	N_W_Heaters
Wide Body Boost Pumps	N_WB_Boost_Pumps	Lavatories	N_Lav
Wide Body Override Pumps	N_WB_Override_Pumps	Range	Range
Wide Body Jettison Pumps	N_WB_Jettison_Pumps		

ASSET EPGDS Method

Airplane Level ATA AC Load Summary by Flight Phase

Top left screen segment:

File Run Goto Report Help

AC Loads Summary by Flight Phase

ATA Subsystems	Pass Loading kVA	Pass Loading PF	Engine Start kVA	Engine Start PF	Taxi Out kVA	Taxi Out PF
21 Air Conditioning	PLL[01]	PLPF[01]	ESL[01]	ESPF[01]	TOL[01]	TOPF[01]
22 Auto Flight	PLL[02]	PLPF[02]	ESL[02]	ESPF[02]	TOL[02]	TOPF[02]
23 Communications	PLL[03]	PLPF[03]	ESL[03]	ESPF[03]	TOL[03]	TOPF[03]
24 Electrical Power	PLL[04]	PLPF[04]	ESL[04]	ESPF[04]	TOL[04]	TOPF[04]
25 Equipment/Furnishing	PLL[05]	PLPF[05]	ESL[05]	ESPF[05]	TOL[05]	TOPF[05]
26 Fire Protection	PLL[06]	PLPF[06]	ESL[06]	ESPF[06]	TOL[06]	TOPF[06]
27 Flight Control	PLL[07]	PLPF[07]	ESL[07]	ESPF[07]	TOL[07]	TOPF[07]
28 Fuel	PLL[08]	PLPF[08]	ESL[08]	ESPF[08]	TOL[08]	TOPF[08]
29 Hydraulic Power	PLL[09]	PLPF[09]	ESL[09]	ESPF[09]	TOL[09]	TOPF[09]
30 Ice/Rain Protection	PLL[10]	PLPF[10]	ESL[10]	ESPF[10]	TOL[10]	TOPF[10]
31 Instruments	PLL[11]	PLPF[11]	ESL[11]	ESPF[11]	TOL[11]	TOPF[11]
32 Landing Gear	PLL[12]	PLPF[12]	ESL[12]	ESPF[12]	TOL[12]	TOPF[12]
33 Lights	PLL[13]	PLPF[13]	ESL[13]	ESPF[13]	TOL[13]	TOPF[13]
34 Navigation	PLL[14]	PLPF[14]	ESL[14]	ESPF[14]	TOL[14]	TOPF[14]
35 Oxygen	PLL[15]	PLPF[15]	ESL[15]	ESPF[15]	TOL[15]	TOPF[15]
36 Pneumatics	PLL[16]	PLPF[16]	ESL[16]	ESPF[16]	TOL[16]	TOPF[16]
38 Water/Waste	PLL[17]	PLPF[17]	ESL[17]	ESPF[17]	TOL[17]	TOPF[17]
46 Electronic Library	PLL[18]	PLPF[18]	ESL[18]	ESPF[18]	TOL[18]	TOPF[18]
49 Airplane Auxiliary Power	PLL[19]	PLPF[19]	ESL[19]	ESPF[19]	TOL[19]	TOPF[19]
52 Doors	PLL[20]	PLPF[20]	ESL[20]	ESPF[20]	TOL[20]	TOPF[20]
57 Folding Wing	PLL[21]	PLPF[21]	ESL[21]	ESPF[21]	TOL[21]	TOPF[21]
73 Engine Fuel Control	PLL[22]	PLPF[22]	ESL[22]	ESPF[22]	TOL[22]	TOPF[22]
74 Ignition	PLL[23]	PLPF[23]	ESL[23]	ESPF[23]	TOL[23]	TOPF[23]
75 Air	PLL[24]	PLPF[24]	ESL[24]	ESPF[24]	TOL[24]	TOPF[24]
76 Engine Controls	PLL[25]	PLPF[25]	ESL[25]	ESPF[25]	TOL[25]	TOPF[25]

ASSET EPGDS Method

Airplane Level ATA AC Load Summary by Flight Phase

The top right screen segment:

File Run Goto Report Help

AC Loads Summary by Flight Phase

ATA Subsystems	Take-off & Climb kVA	Take-off & Climb PF	Cruise kVA	Cruise PF	Descent & Land kVA	Descent & Land PF
21 Air Conditioning	TCL[01]	TCPF[01]	CrL[01]	CrPF[01]	DLL[01]	DLPF[01]
22 Auto Flight	TCL[02]	TCPF[02]	CrL[02]	CrPF[02]	DLL[02]	DLPF[02]
23 Communications	TCL[03]	TCPF[03]	CrL[03]	CrPF[03]	DLL[03]	DLPF[03]
24 Electrical Power	TCL[04]	TCPF[04]	CrL[04]	CrPF[04]	DLL[04]	DLPF[04]
25 Equipment/Furnishing	TCL[05]	TCPF[05]	CrL[05]	CrPF[05]	DLL[05]	DLPF[05]
26 Fire Protection	TCL[06]	TCPF[06]	CrL[06]	CrPF[06]	DLL[06]	DLPF[06]
27 Flight Control	TCL[07]	TCPF[07]	CrL[07]	CrPF[07]	DLL[07]	DLPF[07]
28 Fuel	TCL[08]	TCPF[08]	CrL[08]	CrPF[08]	DLL[08]	DLPF[08]
29 Hydraulic Power	TCL[09]	TCPF[09]	CrL[09]	CrPF[09]	DLL[09]	DLPF[09]
30 Ice/Rain Protection	TCL[10]	TCPF[10]	CrL[10]	CrPF[10]	DLL[10]	DLPF[10]
31 Instruments	TCL[11]	TCPF[11]	CrL[11]	CrPF[11]	DLL[11]	DLPF[11]
32 Landing Gear	TCL[12]	TCPF[12]	CrL[12]	CrPF[12]	DLL[12]	DLPF[12]
33 Lights	TCL[13]	TCPF[13]	CrL[13]	CrPF[13]	DLL[13]	DLPF[13]
34 Navigation	TCL[14]	TCPF[14]	CrL[14]	CrPF[14]	DLL[14]	DLPF[14]
35 Oxygen	TCL[15]	TCPF[15]	CrL[15]	CrPF[15]	DLL[15]	DLPF[15]
36 Pneumatics	TCL[16]	TCPF[16]	CrL[16]	CrPF[16]	DLL[16]	DLPF[16]
38 Water/Waste	TCL[17]	TCPF[17]	CrL[17]	CrPF[17]	DLL[17]	DLPF[17]
46 Electronic Library	TCL[18]	TCPF[18]	CrL[18]	CrPF[18]	DLL[18]	DLPF[18]
49 Airplane Auxilary Power	TCL[19]	TCPF[19]	CrL[19]	CrPF[19]	DLL[19]	DLPF[19]
52 Doors	TCL[20]	TCPF[20]	CrL[20]	CrPF[20]	DLL[20]	DLPF[20]
57 Folding Wing	TCL[21]	TCPF[21]	CrL[21]	CrPF[21]	DLL[21]	DLPF[21]
73 Engine Fuel Control	TCL[22]	TCPF[22]	CrL[22]	CrPF[22]	DLL[22]	DLPF[22]
74 Ignition	TCL[23]	TCPF[23]	CrL[23]	CrPF[23]	DLL[23]	DLPF[23]
75 Air	TCL[24]	TCPF[24]	CrL[24]	CrPF[24]	DLL[24]	DLPF[24]
76 Engine Controls	TCL[25]	TCPF[25]	CrL[25]	CrPF[25]	DLL[25]	DLPF[25]

ASSET EPGDS Method

Airplane Level ATA AC Load Summary by Flight Phase

The bottom left screen segment:

File Run Goto Report Help

AC Loads Summary by Flight Phase

	Pass Loading		Engine Start		Taxi Out	
ATA Subsystems	kVA	PF	kVA	PF	kVA	PF
77 Engine Indicating	PLL[26]	PLPF[26]	ESL[26]	ESPF[26]	TOL[26]	TOPF[26]
78 Exhaust	PLL[27]	PLPF[27]	ESL[27]	ESPF[27]	TOL[27]	TOPF[27]
79 Oil	PLL[28]	PLPF[28]	ESL[28]	ESPF[28]	TOL[28]	TOPF[28]
80 Starting	PLL[29]	PLPF[29]	ESL[29]	ESPF[29]	TOL[29]	TOPF[29]
Flight Phase Subtotals	PLSTL	PLSTPF	ESSTL	ESSTPF	TOSTL	TOSTPF
Error/Growth Factor (15%)	PLGFL	PLGFPF	ESGFL	ESGFPF	TOGFL	TOGFPF
Flight Phase Totals	PLTLL	PLTLPF	ESTLL	ESTLPF	TOTLL	TOTLPF
Maximum Flight Phase Load	MFPL	MFPPF				

Essential AC Loads Worksheet

Screen for Essential AC Loads:

File Run Goto Report Help

Essential AC Loads

	Quantity		Load per Unit	Total
Fan Loads				Fan_Total_load kVA
Upper Recirc	N_Upr_Recirc_Fans	@	Upr_Recirc_Fan_load kVA	
Lower Recirc	N_Lwr_Recirc_Fans	@	Lwr_Recirc_Fan_load kVA	
Equip. Cool Supply	N_EEC_Supply_Fans	@	EEC_Supply_Fan_load kVA	
Equip. Cool Vent	N_EEC_Vent_Fans	@	EEC_Vent_Fan_load kVA	
Pump Loads				Pump_Total_load kVA
Hydraulic ACMP's	N_Hyd_ACMP_Pumps	@	Hyd_ACMP_Pump_load kVA	
Fuel Boost	N_Fuel_Boost_Pumps	@	Fuel_Boost_Pump_load kVA	
Fuel Override	N_Fuel_Override_Pumps	@	Fuel_Override_Pump_load kVA	
Per Passenger				Per_Passenger_load kVA
Baseline Flight & Electronics				Bsln_FltElec_Total_load kVA
Ice & Rain			Bsln_FltElec_Ice&Rain_load kVA	
Electronics			Bsln_FltElec_Elec_load kVA	
SUBTOTAL				Subtotal_Essential_load kVA
7% General Feeder Losses				General_Feeder_Loss kVA
TOTAL				Total_Essential_load kVA

ASSET EPGDS Method

Loads Worksheet -ATA 21 Air Conditioning

AC Load Calculation Worksheet
Using load inputs from Electrical System Project or Supplier/Vendor

Function	Equipment	Qty	Unit Load kVA	Utilization/ Demand Factor(%)	Connected Load	Normal Operation Average Load (kVA)- Flight Phase: Pass Loading	Engine Start	Taxi Out	Take Off & Climb	Cruise	Land & Descent	Essential Emer/Stdby Load(kVA)
Cabin Air Supply												
	Gasper Fan			100	0	0	0	0	0	0	0	0
	Door Heater			see notes	0	0	0	0	0	0	0	0
	Capt/FO Aux. Heater			see notes	0	0	0	0	0	0	0	0
	Crew Rest Heater			100	0	0	0	0	0	0	0	0
Recirculation Air												
	Recirculation Fan-Lower			100	0	0	0	0	0	0	0	0
	Recirculation Fan-Upper			100	0	0	0	0	0	0	0	0
Lavatories and Galleys												
	Lav/Galley Fan			100	0	0	0	0	0	0	0	0
	Chiller Boost Fan			100	0	0	0	0	0	0	0	0
	Galley Heater			see notes	0	0	0	0	0	0	0	0
Avionics Cooling												
	EE Cooling Fan			100	0	0	0	0	0	0	0	0
Cargo Heating												
	Cargo Heater			100	0	0	0	0	0	0	0	0
	Cargo Vent/Exhaust Fan			100	0	0	0	0	0	0	0	0
IFE Cooling(see note #3)												
	IFE Fan			100	0	0	0	0	0	0	0	0
Misc												
	Sensor, etc			100	0	0	0	0	0	0	0	
	TOTAL LOAD					0	0	0	0	0	0	0

Notes:
1.) Total kVA is simply a summation of the individual load kVA and is not calculated from the real KW & reactive KVAR values
2.) Utilization/Demand Factor mutiplied by Connected Load results in Average Load. Utilization/Demand Load represents percentage of time the system operates during a given mode of operation.
3.) IFE/AVOD Cooling will be carried under IFE/AVOD Load Analysis section

Demand/Utilization Factor:
For Air Conditioning System, Demand factor is 100%, since in general these loads operate continously throughout all modes of operation.

Door Heaters, Galley Heaters and Capt/FO Aux Heaters are operational 100% in flight phase only.

Essential/Emergency Operation:
Assume Recirculating, Lavatory,Galley Fans and all AC utility busses load are shed, E/E cooling fans remain on

CDR Agenda

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1:05 PM	Loads	George Gregorios
1:25 PM	Generation	Ken Perez
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3:50 PM	Review Action Items	Reid Wakefield
4:00 PM	Adjourn	

BOEING

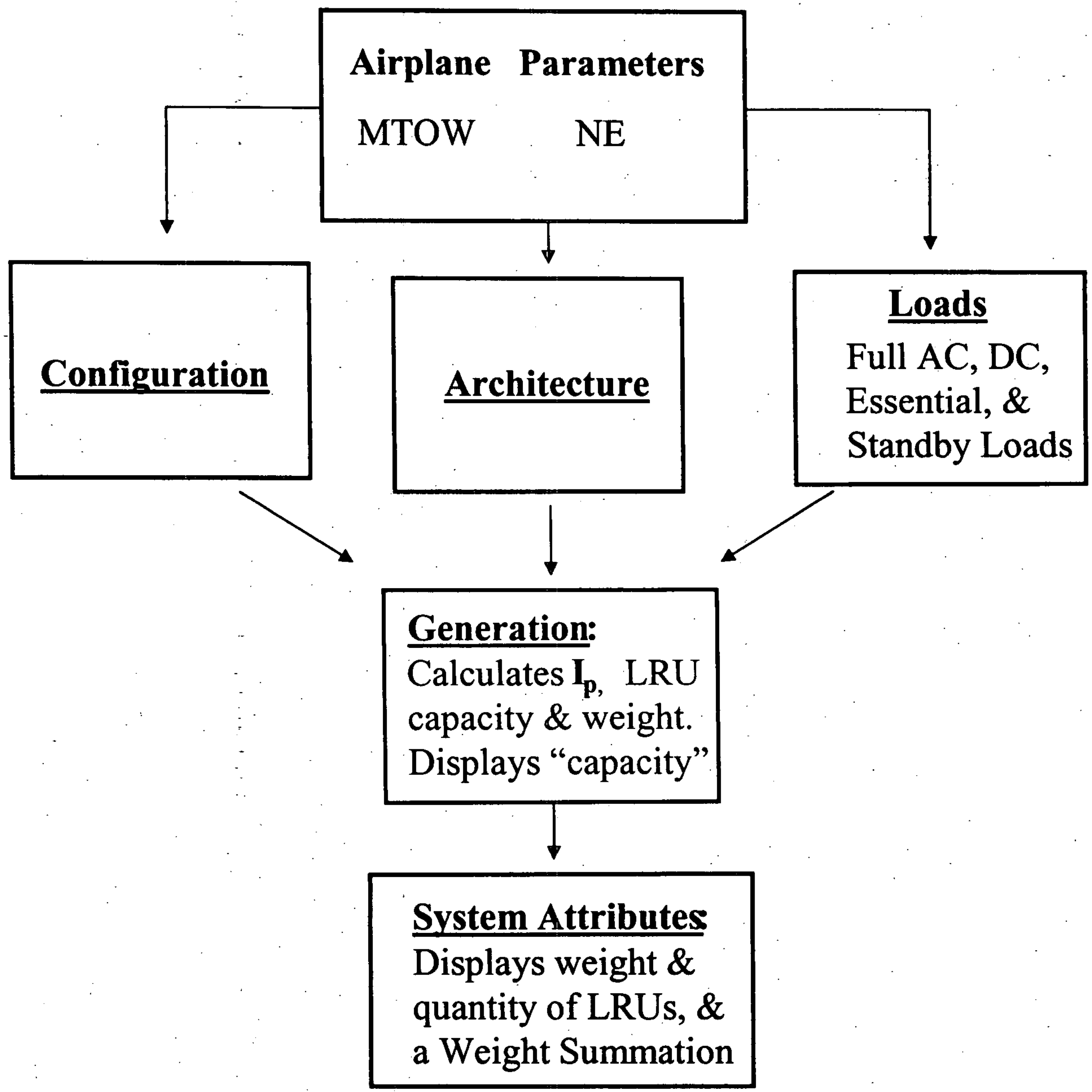
ASSET Electrical Method

Generation

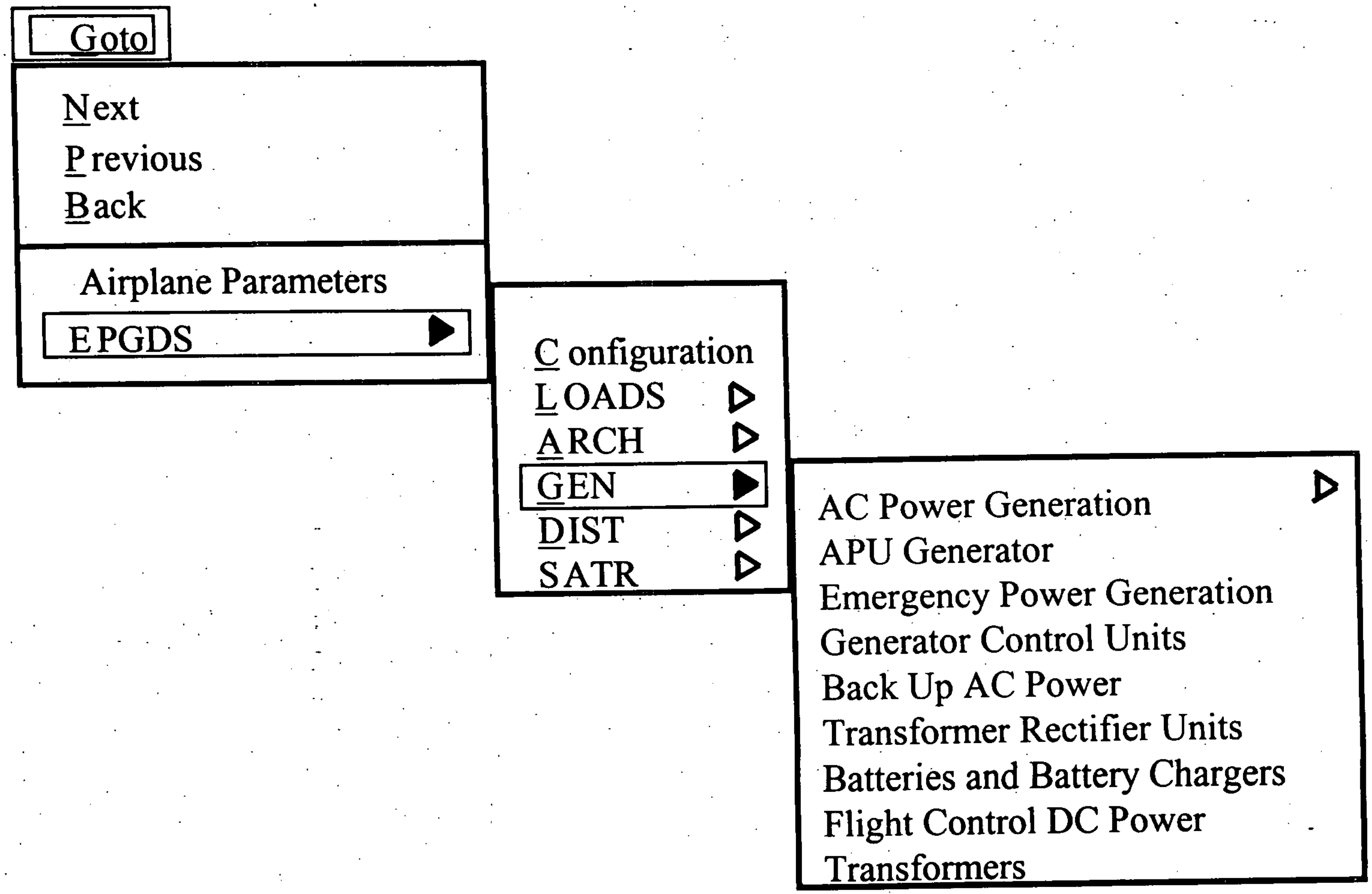
Ken Perez
Weight Engineering

[redacted]

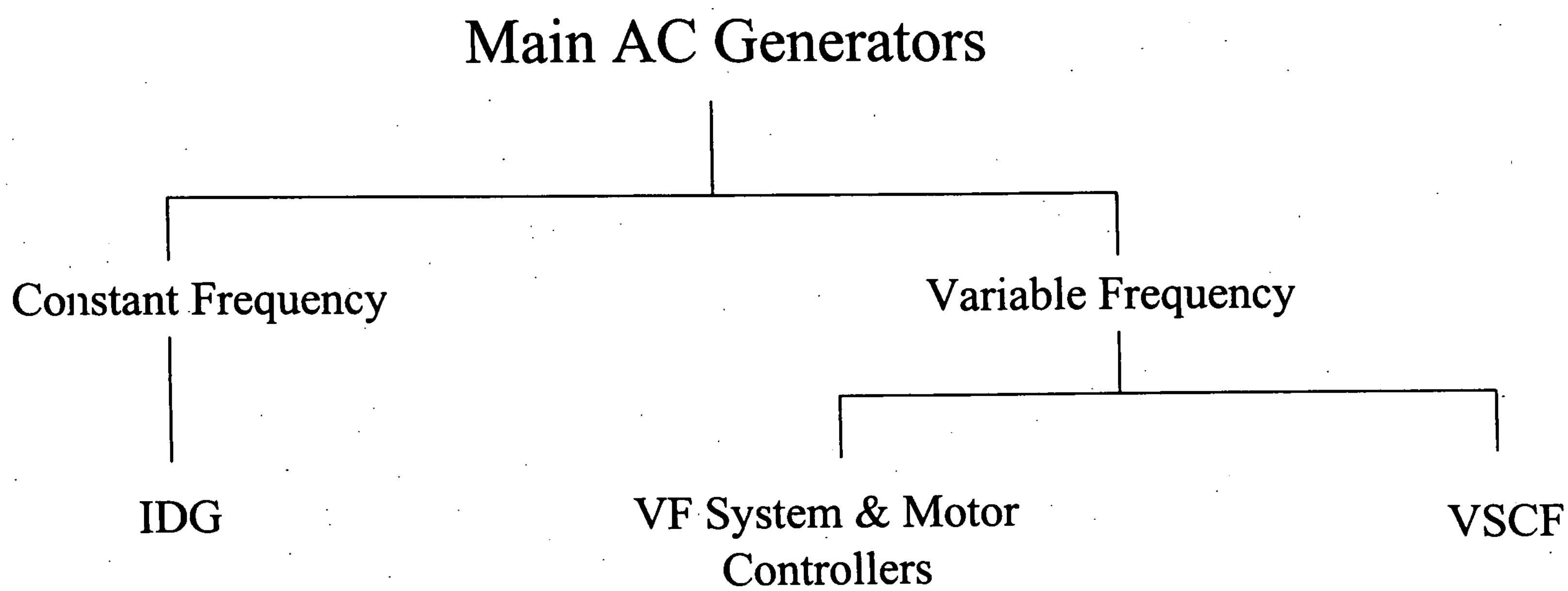
Generation Module Data Flow



Power Generation Pull-Down Menu

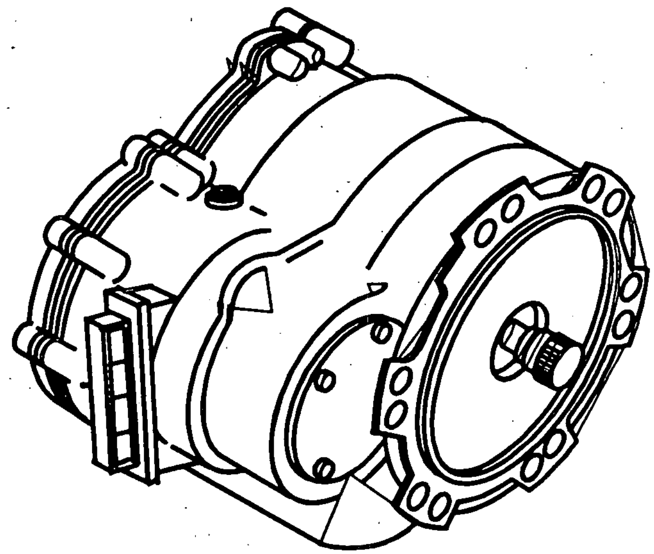


Generator Decision Tree



File Run Goto Report Help

Main AC Power Generation

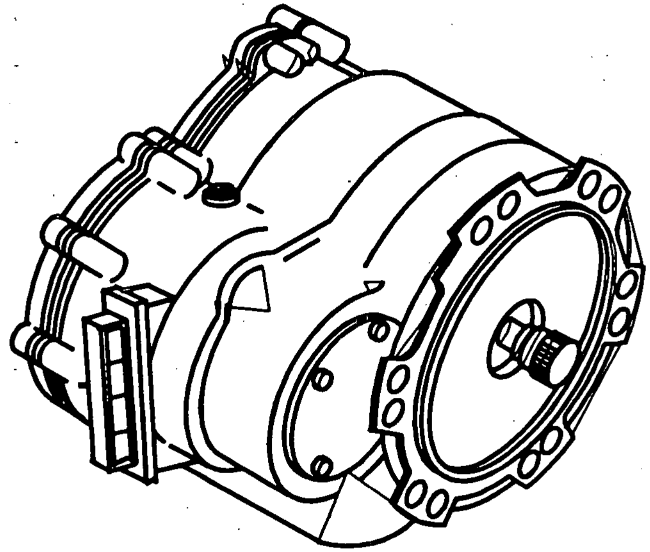


System Frequency Type	AC_Freq_Type	
Generator Type	AC_Gen_Type	
Generator Capacity	Main_Generator_Cap	kVA
Input Speed	Max_Gen_In_Speed	RPM
Method of Cooling	Main_Gen_Cool_Meth	
Generator Unit Weight	Main_Gen_Wt	Lb.

ASSET EPGDS Method

File Run Goto Report Help

Main AC Power Generation



System Frequency Type	Constant	
Generator Type	IDG	
Generator Capacity	90	kVA
Input Speed	12000	RPM
Method of Cooling	Oil	
Generator Unit Weight	111.0	Lb.

ASSET EPGDS Method

VF Power System "Screen Configuration"

- Configuration
- LOADS ▷
- ARCH ▷
- GEN ▶
- DIST ▷
- SATR ▷

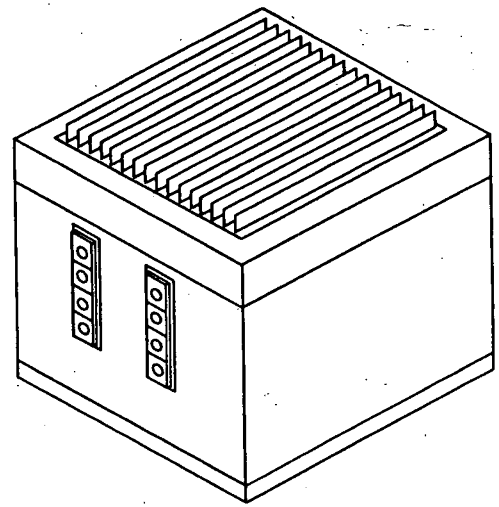
- AC Power Generation ▶
- APU Generator
- Emergency Power Generation
- Generator Control Units
- Back Up AC Power
- Transformer Rectifier Units
- Batteries and Battery Chargers
- Flight Control DC Power
- Transformers

- VF System w/ Motor Controllers
- VF System w/ Converter (VSCF)

File Run Goto Report Help

Motor Controllers for a Variable Frequency System

Motor Controllers (required for AC Induction Motors)



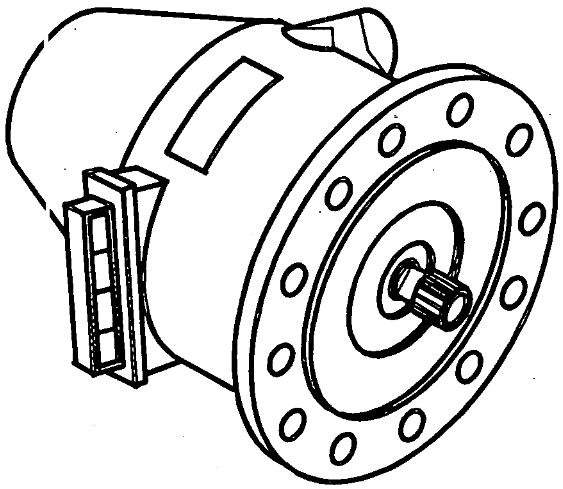
ATA Chapter	Section Title	Max. Connected Load *	Motor Controller Weight
21	Air Conditoning	7.7 kVA	15.4 lb.
25	Equipment Furnishings	20.3 kVA	40.6 lb.
25	Galleys	0.8 kVA	1.6 lb.
26	Fire Protection	0.7 kVA	1.4 lb.
27	Flight Controls	12.0 kVA	24.0 lb.
28	Fuel System	13.2 kVA	26.4 lb.
29	Hydraulic System	16.7 kVA	33.4 lb.
38	Water/Waste	0.3 kVA	0.6 lb.
7X	Engine	1.9 kVA	3.8 lb.
XX	Additional Loads	0.0 kVA	0.0 lb.
		Total Motor Controller Weight	147.2 lb.

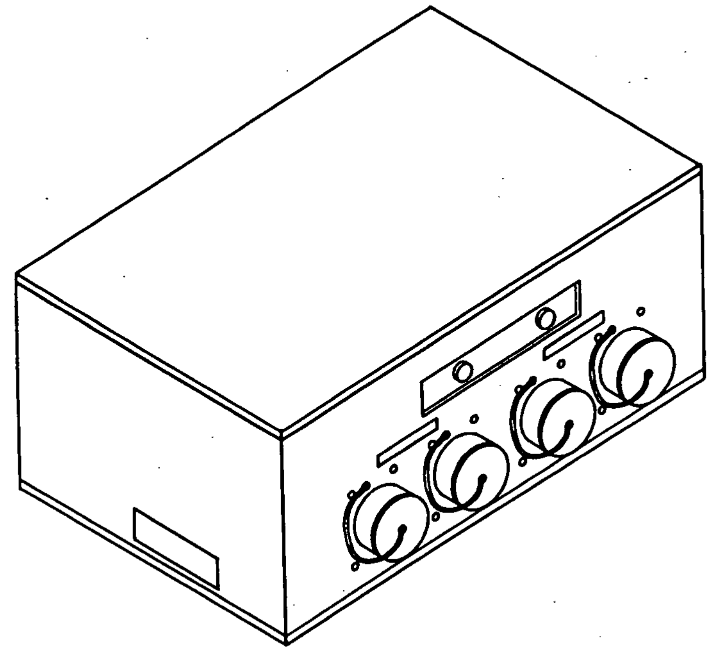
* Values for max. connected loads based upon 4-engine twin aisle airplane power requirements using a variable frequency system.

ASSET EPGDS Method

File Run Goto Report Help

VSCF converter for a Variable Frequency System



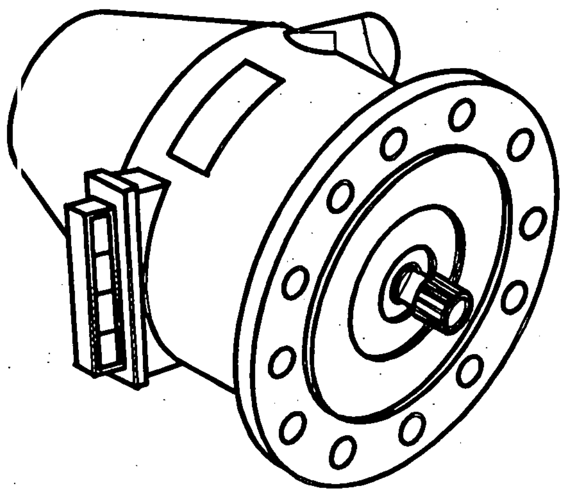


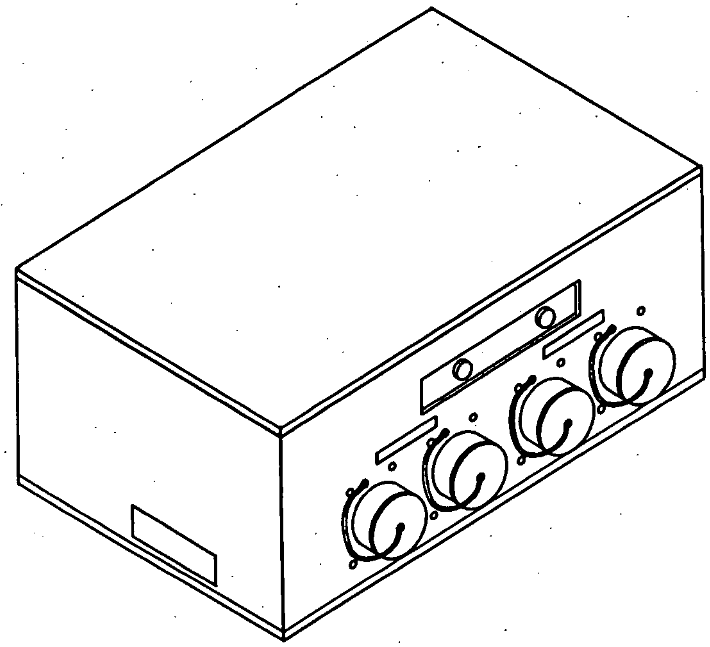
VSCF Converter Configuration	VSCF_Conv_Config	
Maximum Converter Load	Max_Conv_Load	kVA
VSCF Converter Unit Weight	Main_VSCF_Conv_Wt	Lb.

ASSET EPGDS Method

File Run Goto Report Help

VSCF converter for a Variable Frequency System



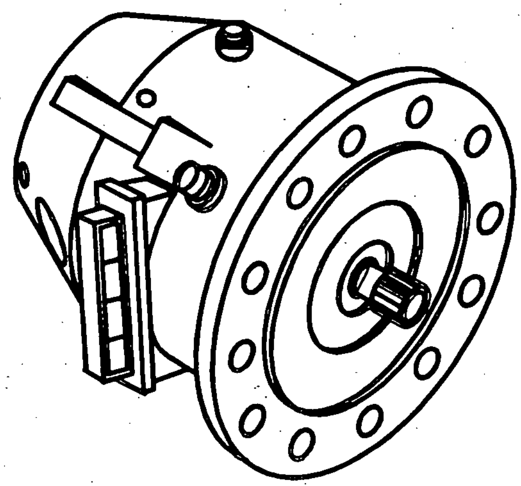


VSCF Converter Configuration	Stand Alone Unit	
Maximum Converter Load	25	kVA
VSCF Converter Unit Weight	57.5	Lb.

ASSET EPGDS Method

File Run Goto Report Help

APU Generator

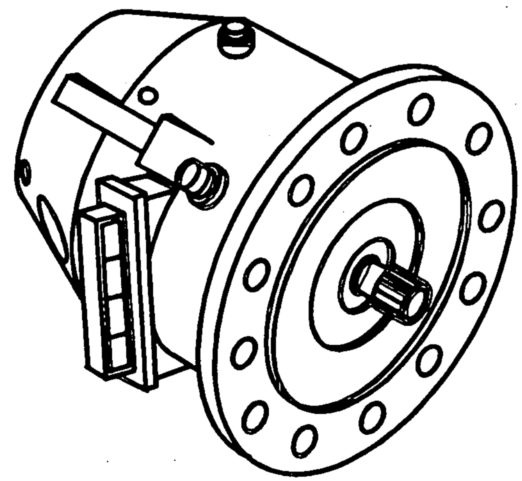


APU Generator Function	APUG_Function	
APU Generator Capacity	APUG_Cap	kVA
APU Generator Weight	APUG_Wt	Lb.

ASSET EPGDS Method

File Run Goto Report Help

APU Generator



APU Generator Function	In-Flight Operable	
APU Generator Capacity	120	kVA
APU Generator Weight	75.2	Lb.

ASSET EPGDS Method

ASSET Electrical Method

Reliability

Paul Covert
RM&T

[redacted]

ASSET EPGDS Reliability Module

- **1 Reliability Inputs screen**
  -- LRU Failure Rates
  -- Engine, APU IFSD Rates
  -- APU Start Rate
  -- RAT, HMG Availability Probabilities (if needed)

  2 or 3 Fault Tree Outputs screens
  -- Loss of All (Non-standby) AC Power
  -- Loss of All (Non-Flight Control) DC Power
  -- Loss of All FCDC Power *(for FBW configurations)*

General Approach to Fault Tree

Depends on configuration:

- 2 or 4 Engines
- FBW or Non-FBW

- **Output probabilities:**

  - Loss of All AC
  - Loss of All non-FC DC
  - Loss of All FC DC

Modeled as "Loss of All Sources"

- (source includes anything equivalent, e.g. GCU, GCB, etc.)

Why Only Consider Sources?

Allows simplicity of model at this stage

Intuitively, safety event probabilities *shouldn't* be driven by smaller components

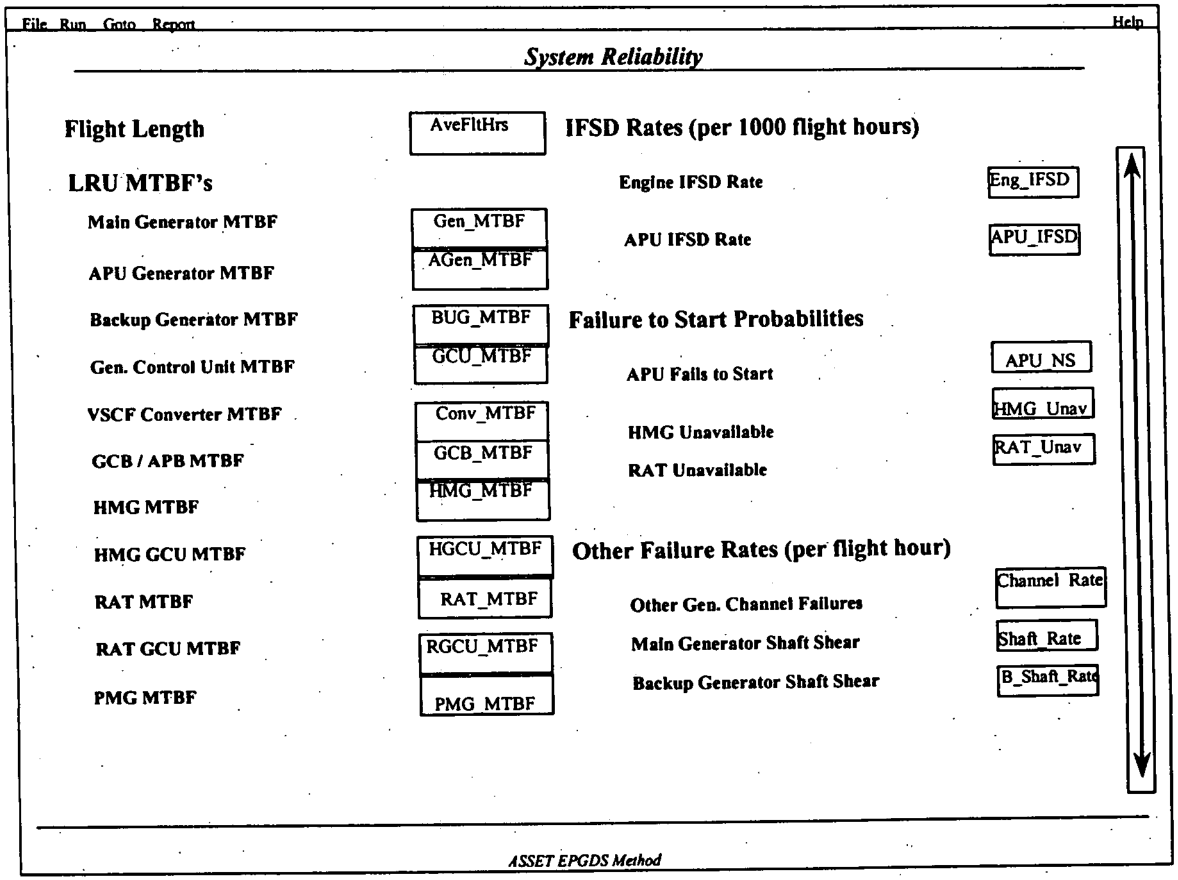
- In practice, safety event probabilities *aren't* driven by smaller components
  - (typically, 4 or more significant figures unaffected)

Therefore, no need for added complexity

Probabilities Required in Model

Equipment with Failure Rates or Availability Probabilities Needed	Quad FBW	Quad Non-FBW	Twin FBW	Twin Non-FBW
Main Gen, GCU, GCB, Engine, Other Gen Channel	X	X	X	X
Aux Gen, APU	X	?	X	X
RAT, RAT GCU, PMG	X		X	
Main Gen Shaft	X			
BUG, BUG Shaft			X	
HMG, HMG GCU				?

Reliability Inputs Screen



Loss of All Non-standby AC Power

Includes the following sources:

- -- All Main AC generators
- -- APU Generators (unless option declined in Quad Non-FBW configuration)
- -- Backup Generators (only in Twin FBW config.)
- -- Hydraulic Motor Generator (if option chosen in Twin Non-FBW configuration)

Loss of All Non FC DC Power

Includes the following sources:

- -- All Main AC generators
- -- APU Generators (unless option declined in Quad Non-FBW configuration)
- -- Backup Generators (only in Twin FBW config.)
- -- Hydraulic Motor Generator (if option chosen in Twin Non-FBW configuration)
- -- RAT Generator (in FBW configurations)

Loss of all FC DC Power

- Only used in FBW configurations

  Includes the following sources:
  - All Main AC generators
  - APU Generators (unless option declined in Quad Non-FBW configuration)
  - Backup Generators (only in Twin FBW config.)
  - Hydraulic Motor Generator (if option chosen in Twin Non-FBW configuration)
  - RAT Generator
  - PMG's (on Main Gen. for Quad, on BUG for Twin)

Relationship of channels *(visible in ASSET)* to basic events *(not visible)*

Channel	Basic Events
Main Generator	Generator, Engine IFSD, GCU, GCB, "other channel faults" (e.g. feeder faults, CT faults, etc.)
APU Generator	APU No-start, APU IFSD, APU GCU, APB, "other channel faults"
Backup Power	Converter, Left AND Right (Backup Generator, Engine,
HMG	HMG Unavailable, HMG IFSD, HMG GCU
RAT	RAT Unavailable, RAT IFSD, RAT GCU
PMG	PMG, Main or Backup Generator Shaft (as appropriate), Engine

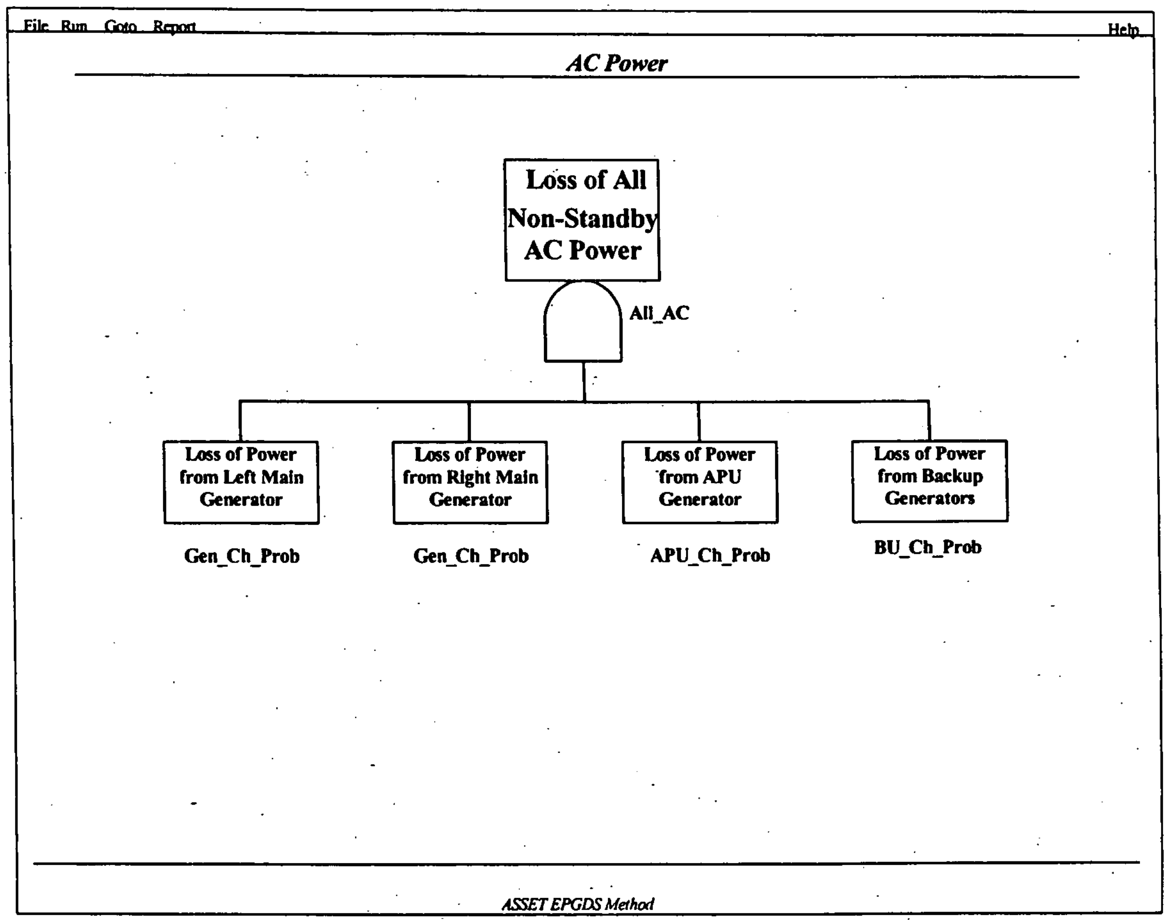
Example of Fault Trees:
Twin FBW (baseline 777)

ASSET screens show only top level

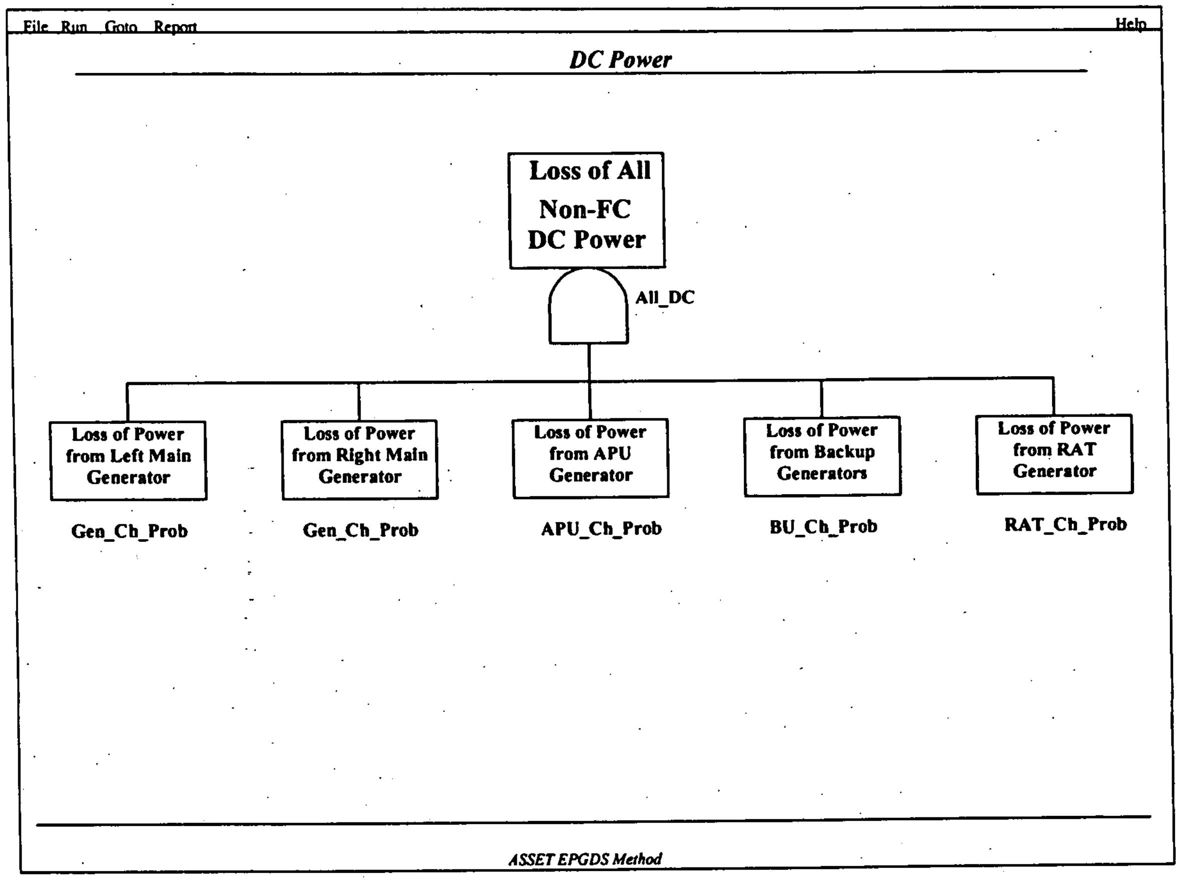
IRAP calculates values based on input line items

Top event probability may not equal product of second-level probabilities due to multiply occurring events *(e.g. Engine IFSD affects both Main and Backup Generators)*

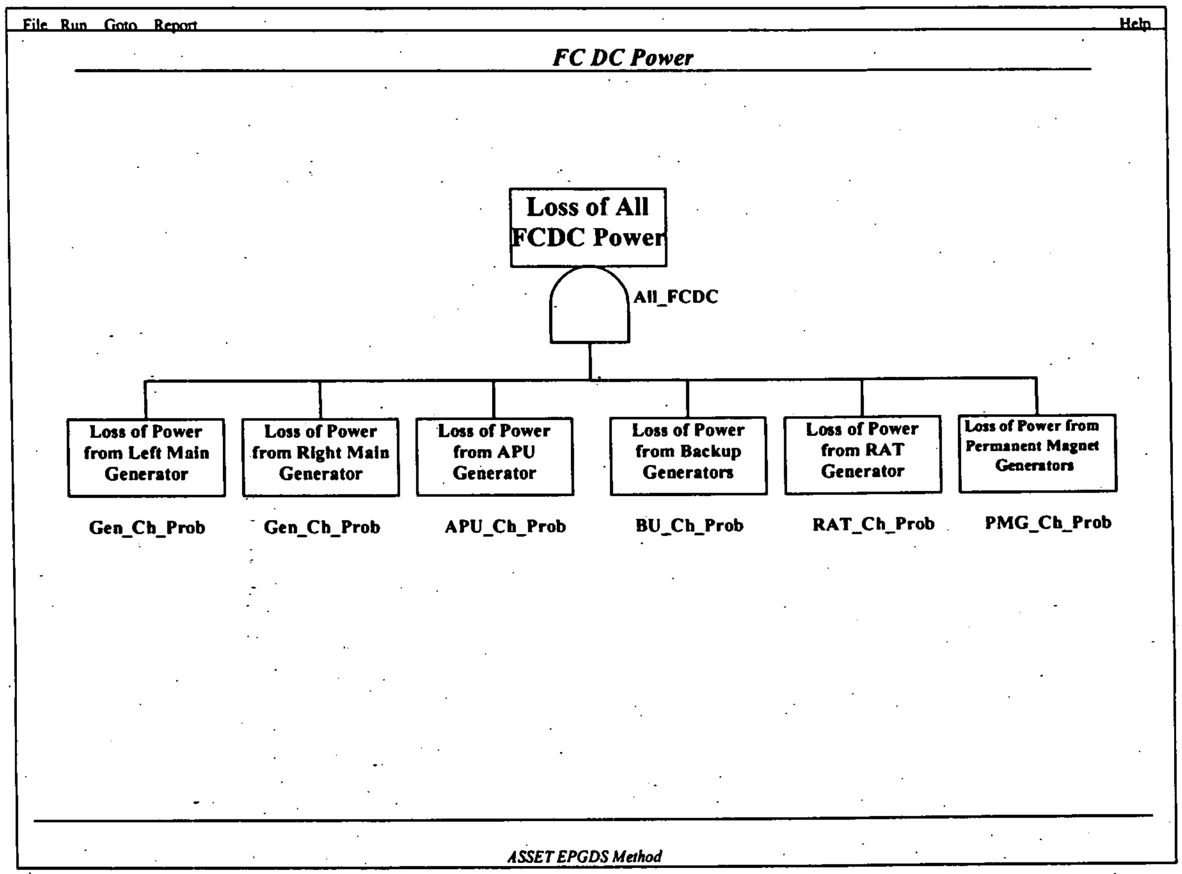
AC Power Fault Tree (Twin FBW)



DC Power Fault Tree (Twin FBW)



FCDC Power Fault Tree (Twin FBW)



CDR Agenda

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ASSET Electrical Method

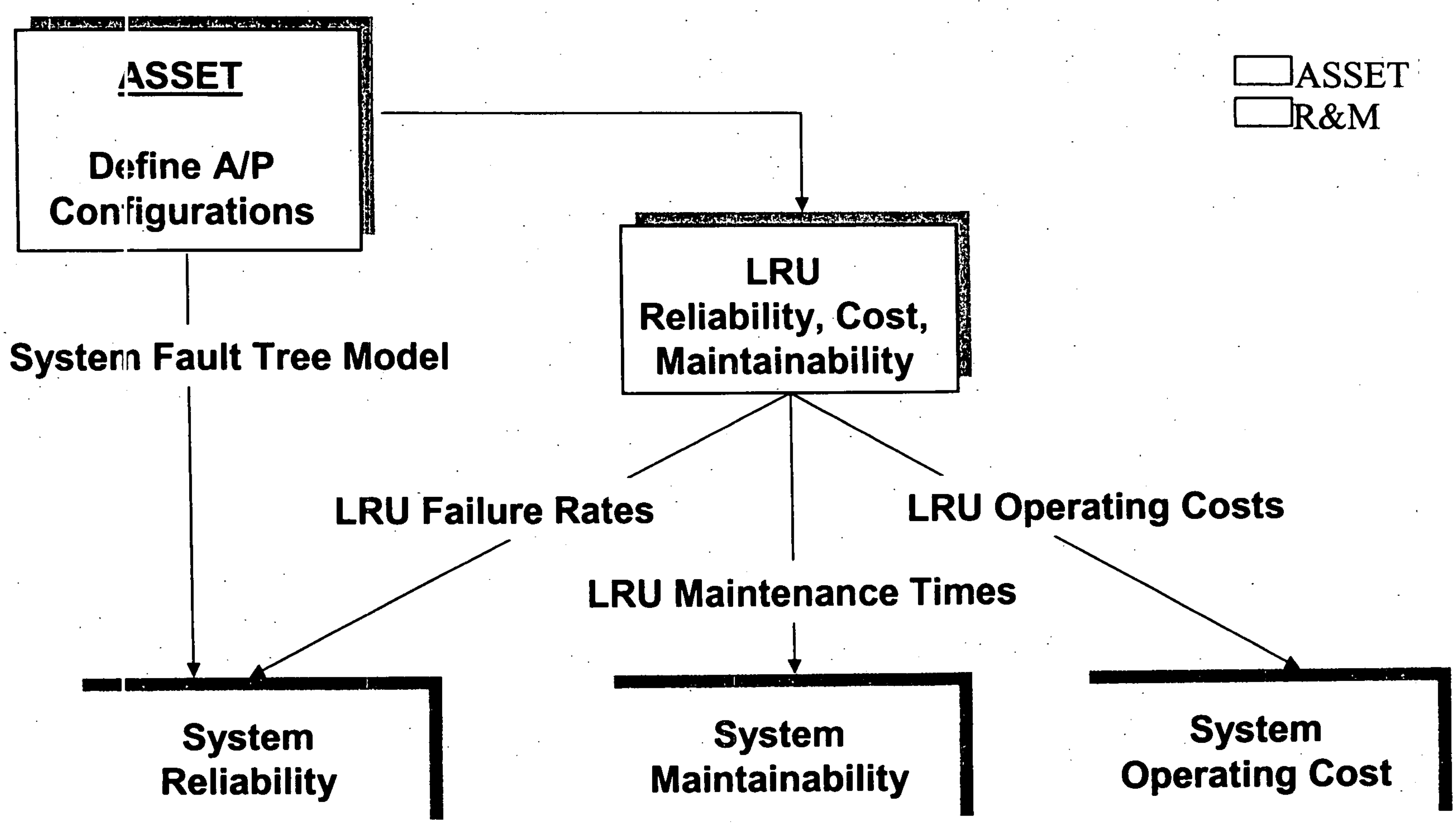
IRAP Tools

David W. Twigg
RM&T, Tools & Methods Research
[redacted]

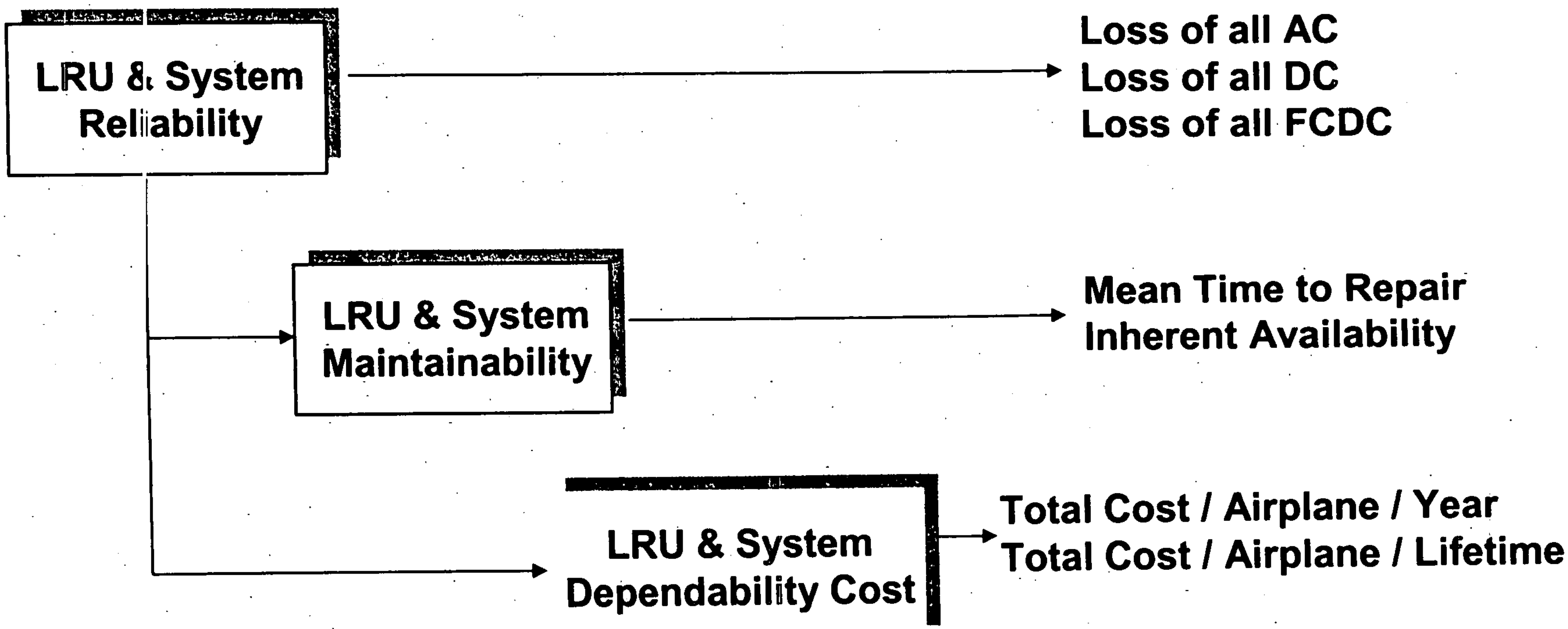
Agenda

- Introduction
  - EGPDS Method
  - RM&T Team Role
- IRAP Tool Overview
- IRAP Tool Application
  - Electrical Module
  - Hydraulics Module
- IRAP Tool Integration

EPGDS Modeling Approach



R&M Outputs



LRU & System Reliability
Loss of all AC
Loss of all DC
Loss of all FCDC
LRU & System Maintainability
Mean Time to Repair
Inherent Availability
LRU & System Dependability Cost
Total Cost / Airplane / Year
Total Cost / Airplane / Lifetime

R&M Tools

Provide Integrated Set of Analysis Tools

- Fault Tree Tools
  (SETS, BDD)
- Markov Tools
  (EHARP, SHARPE)
- Stochastic Petri Net Tools
  (SPNP)
- Durability Analysis Tools
  (FSAP, CALCE)

Validated by In-Service Data

- R&M Data
- Suppliers Data
- NPRD, FMD
- Dependability Cost
- 777 In-Service Data System

IRAP

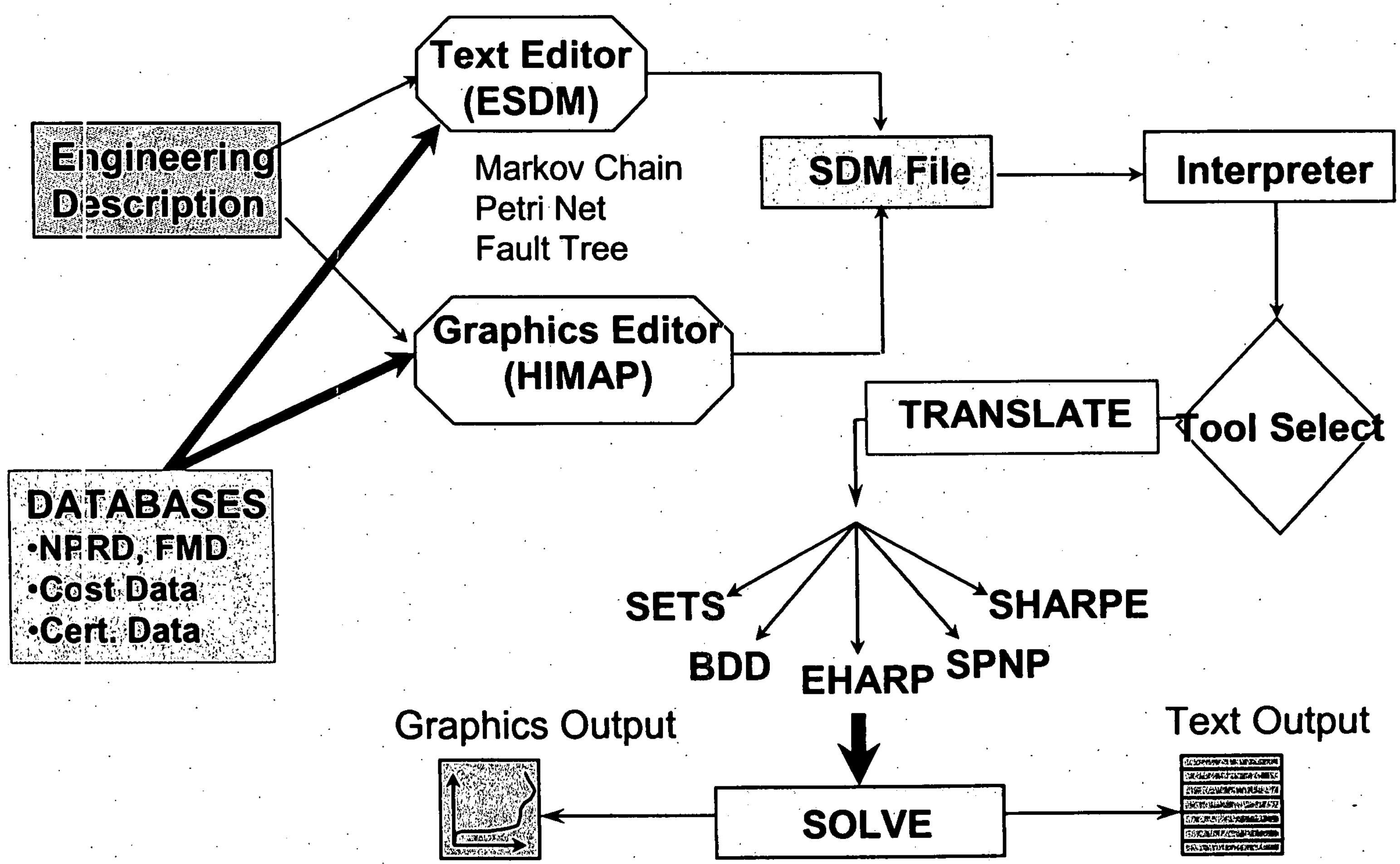
A/P Level Analysis

- Model Database
- LRU Database
- Hierarchical Modeling
- System Dependencies

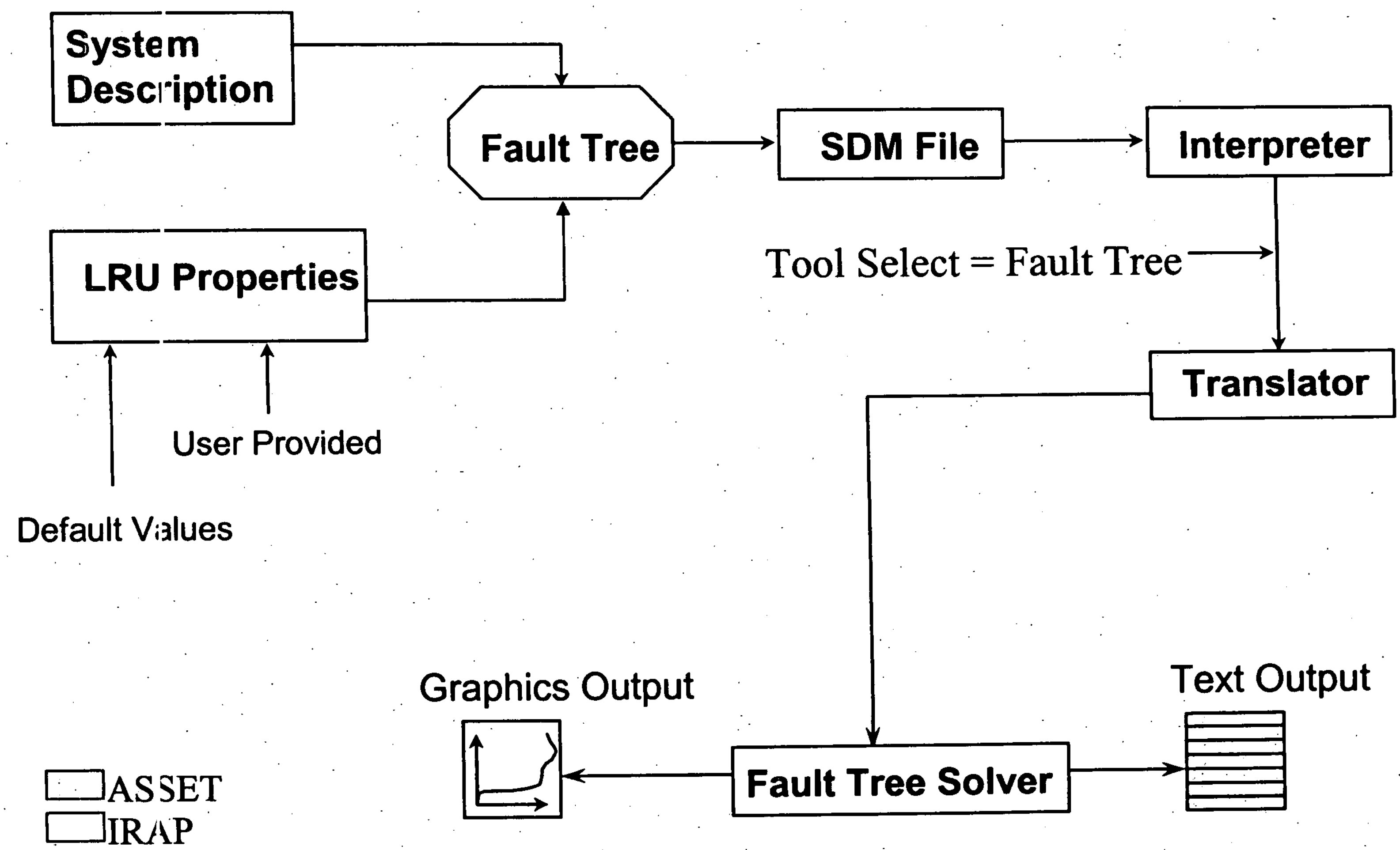
Driven By Requirements

- FAR/JAR

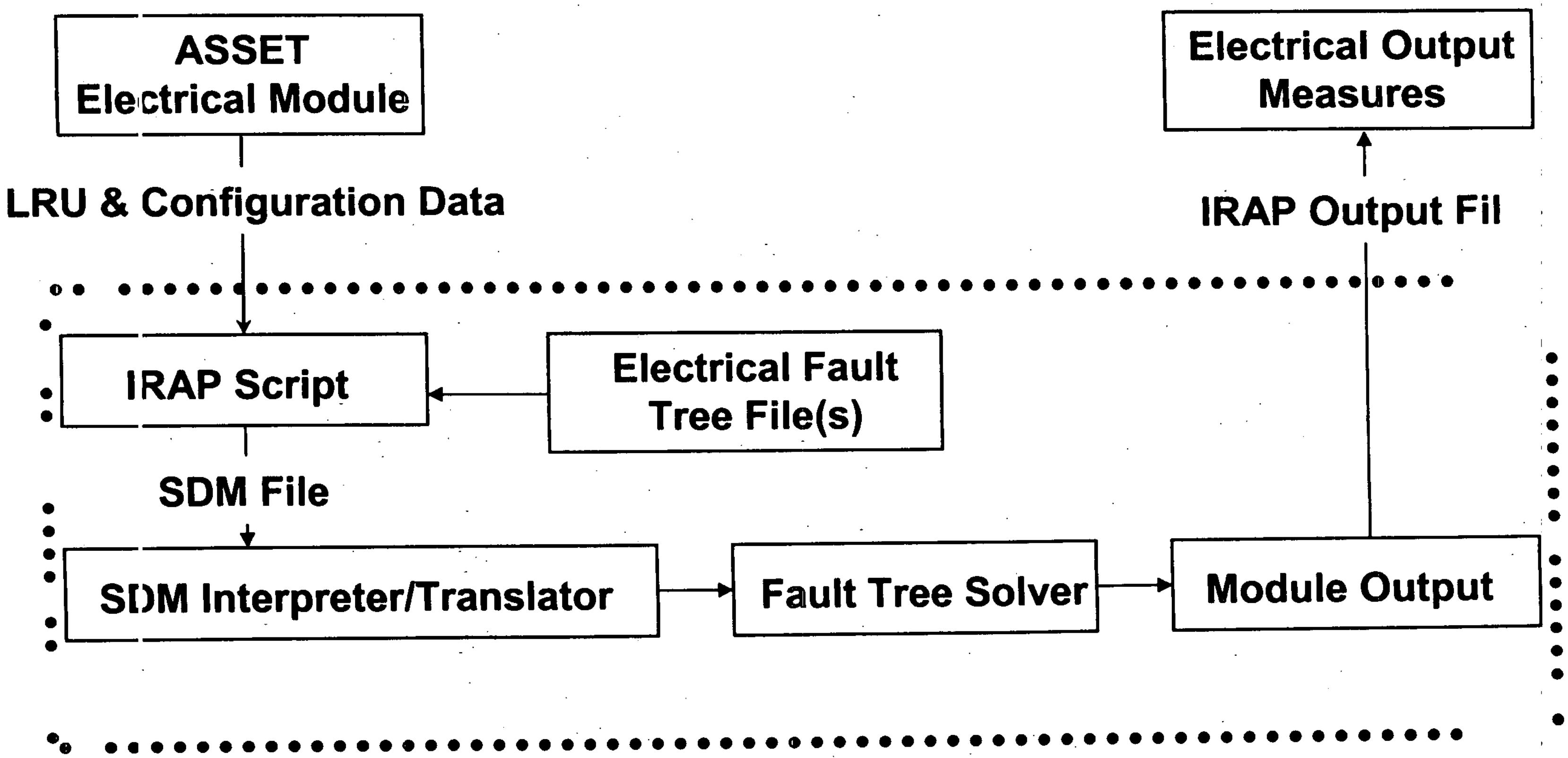
IRAP Data Flow



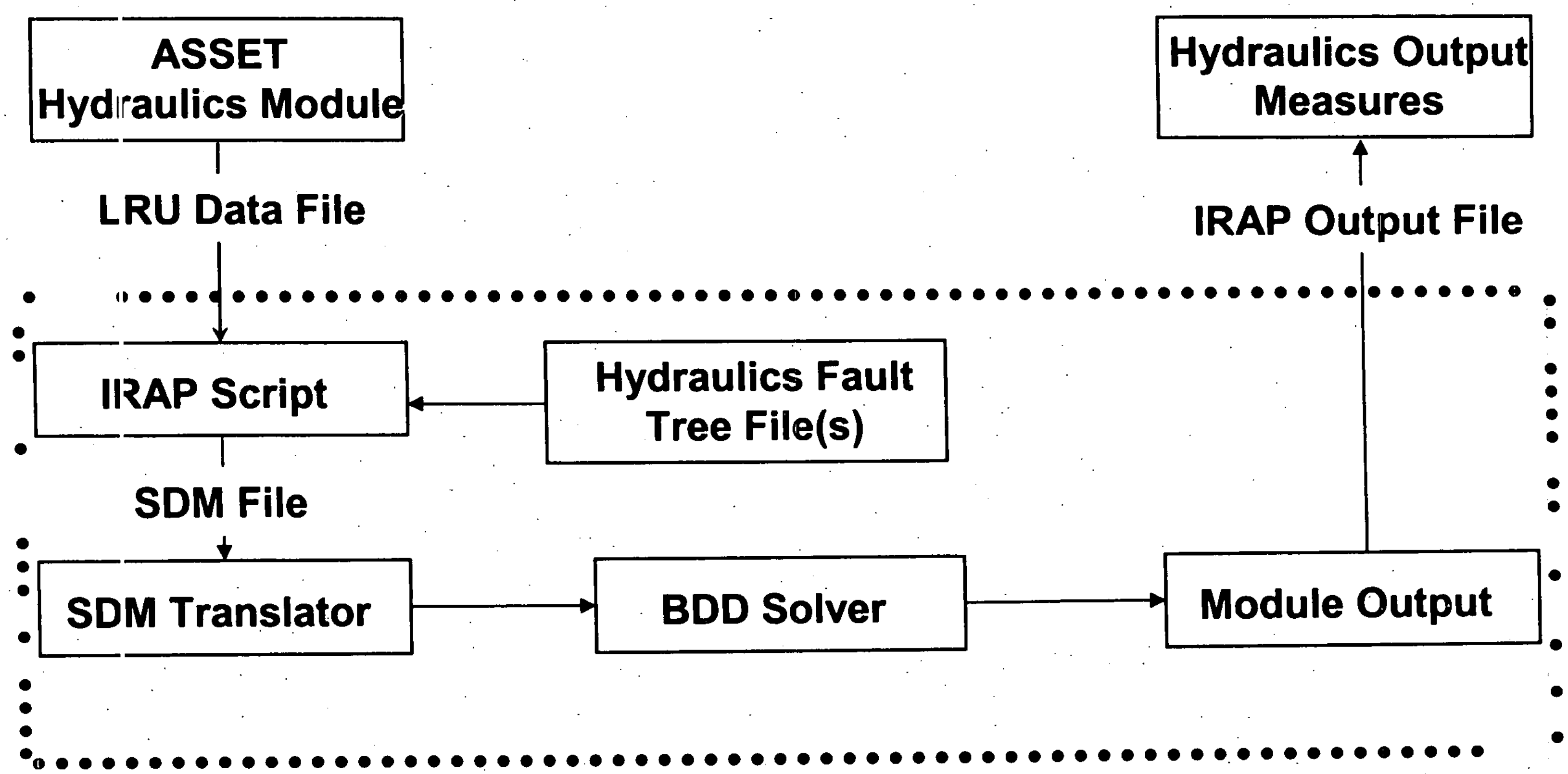
Integration with ASSET



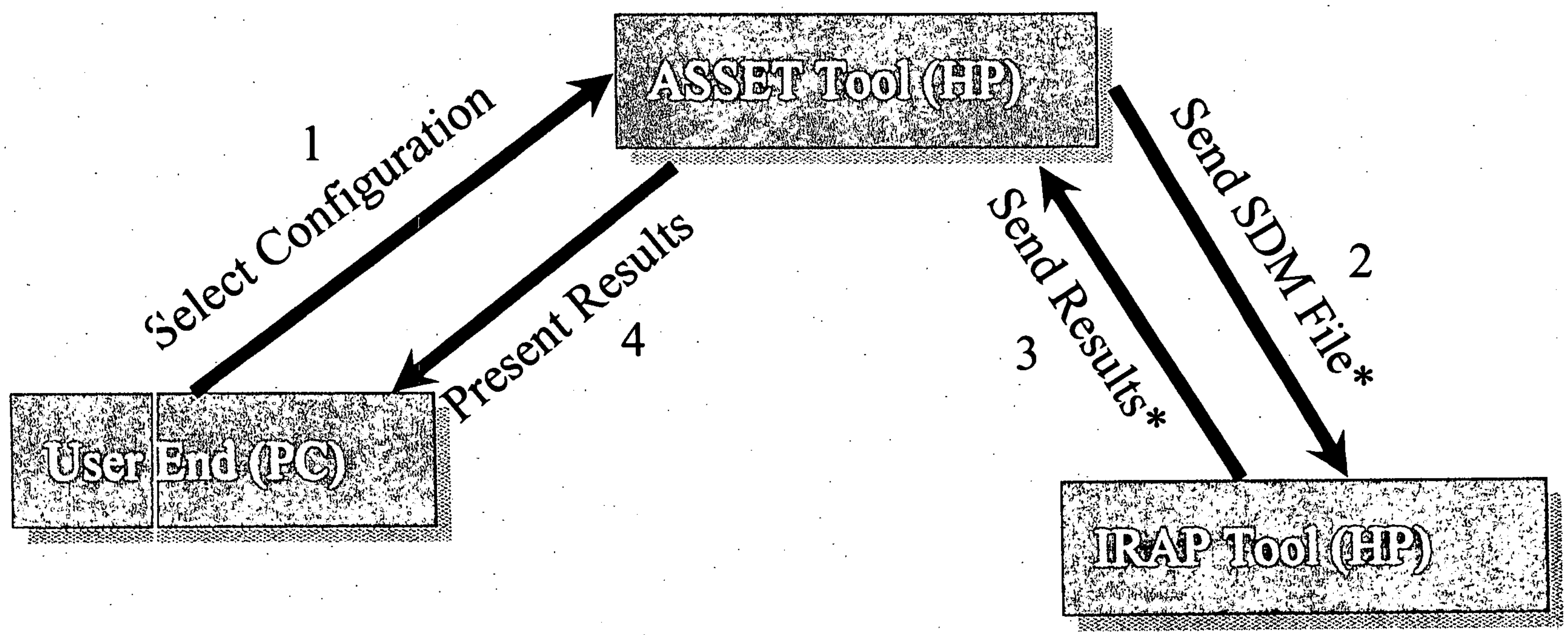
ASSET Electrical Module



ASSET Hydraulics Module

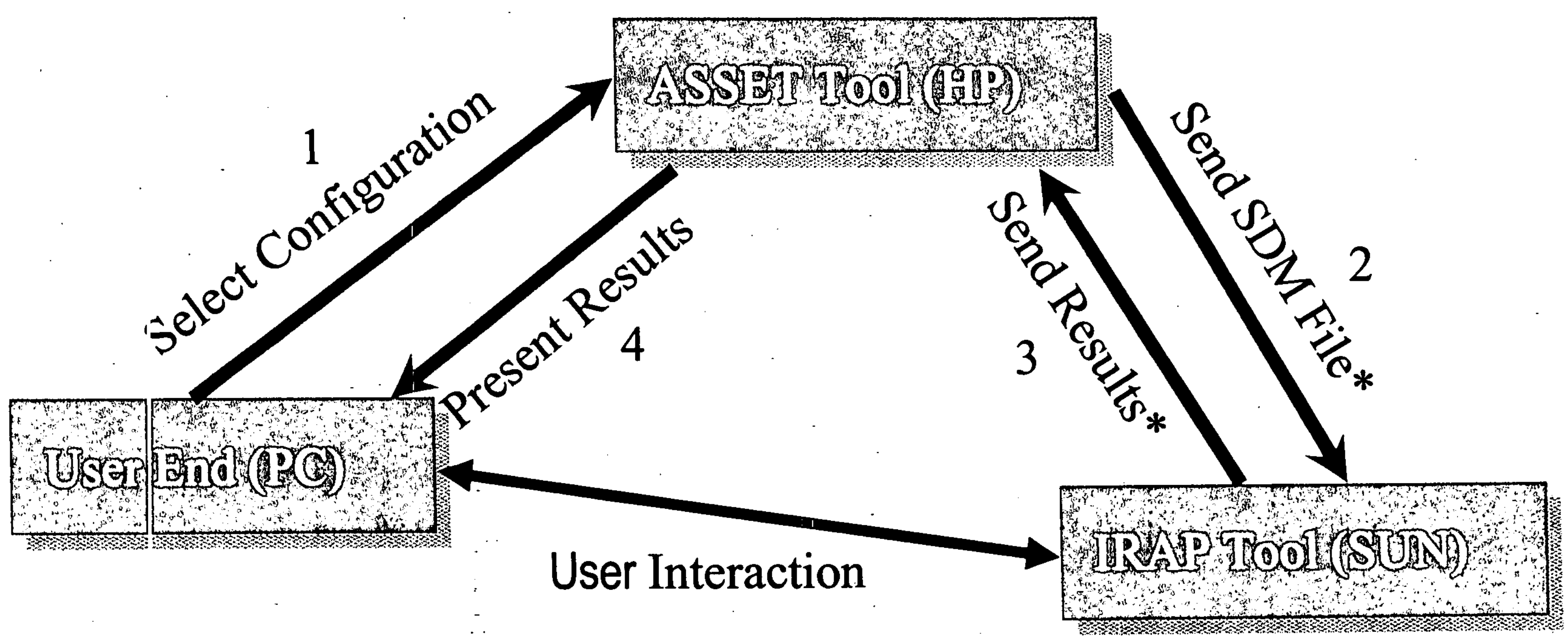


IRAP/ASSET Integration - I



*: R&M tools will be run on same machine as ASSET server

IRAP/ASSET Integration - II



*: R&M tools will be run on IRAP server

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ASSET Electrical Method

Maintainability

Paul M. Covert
RM&T

[redacted]

ASSET EPGDS
Maintainability Module

- Calculates Inherent Availability (IA) for the Main Generator system

Contains three screens:

-- Maintenance Corrective Times screen

-- Maintenance Preparation Times screen

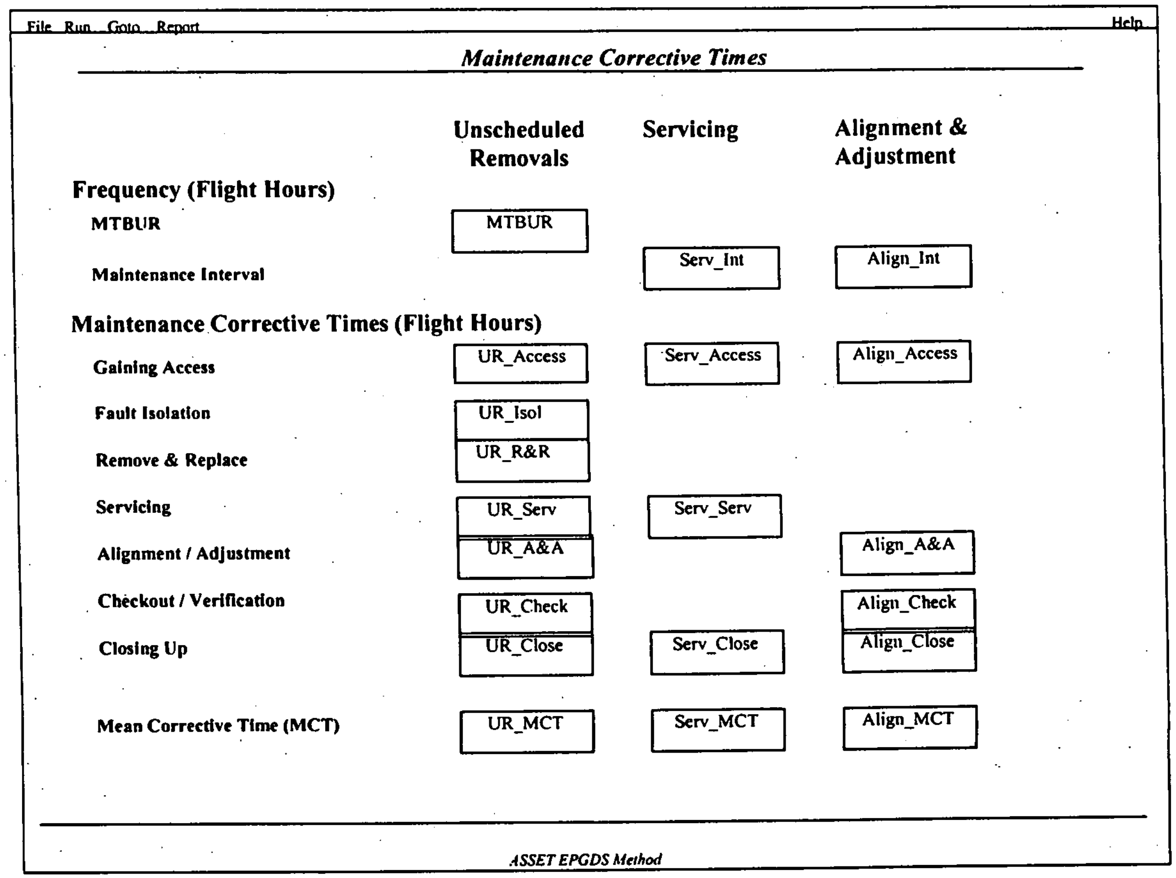
-- Inherent Availability screen

Maintenance Corrective Times

- Calculates Mean Corrective Time (MCT) for Unscheduled Removals, Servicing, and Alignment & Adjustment
- Includes several Maintenance Corrective Time inputs for each type of maintenance
- Sums those inputs to arrive at MCT for each type of maintenance

  Also requires input of each maintenance frequency

Maintenance Corrective Times Screen



Maintenance Preparation Times

- Calculates Mean Preparation Time (MPT) for Unscheduled Removals, Servicing, and Alignment & Adjustment
- Includes several Maintenance Preparation Time inputs for each type of maintenance

  Sums those inputs to arrive at MPT for each type of maintenance

Maintenance Preparation Times Screen

File Run Goto Report Help

Maintenance Preparation Times

	Unscheduled Removals	Servicing	Alignment & Adjustment
Maintenance Preparation Times (Flight Hours)			
Maintenance Coordination	UR_Coord	Serv_Coord	Align_Coord
Dispatch Schedule Delay	UR_Disp_Del		
Ferrying Airplane	UR_Ferry		
Supply Delay	UR_Supp_Del	Serv_Supp_Del	
Issuing Spares & Equipment	UR_Spares		Align_Spares
Transport Delay	UR_Trans_Del		
Maintenance Delay	UR_Maint_Del	Serv_Maint_Del	Align_Maint_De
Maintenance Preparation Time (MCT)	UR_MPT	Serv_MPT	Align_MPT

ASSET EPGDS Method

Inherent Availability Calculation

- The Mean Maintenance Preparation Time (MMPT) and Mean Time To Repair (MTTR) are weighted averages of the MPT and MCT for the three types of maintenance

  The Mean Maintenance Down Time (MMDT) is the sum of these
- The Mean Time Between Maintenance (MTBM) is found by combining the Unscheduled Removal, Servicing, and Alignment/Adjustment frequencies
- The Inherent Availability is calculated by the model as MTBM / (MTBM + MMDT)

Inherent Availability Screen

File Run Goto Report Help

Inherent Availability

Maintenance Preparation Times (Flight Hours)

Mean Time To Repair (MTTR)	MTTR
Mean Maintenance Preparation Time (MMPT)	MMPT
Mean Maintenance Down Time (MMDT)	MMDT
Mean Time Between Maintenance (MTBM)	MTBM

Inherent Availability (IA)	IA

ASSET EPGDS Method

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ASSET Electrical Method

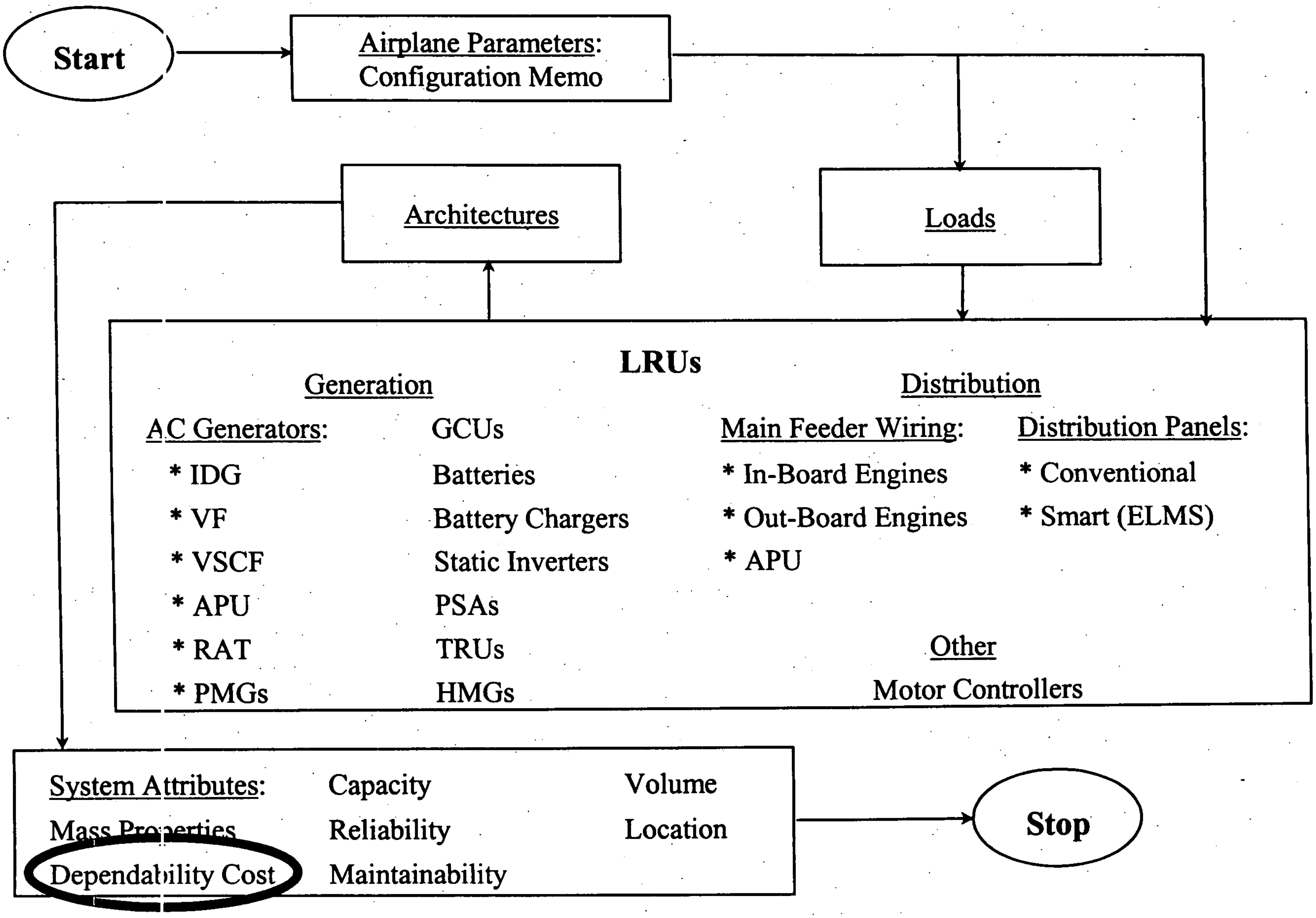
Dependability Cost

Mahyar Rahbarrad

RM&T Airline Cost Analysis Group

[redacted]

Method Process Flow Diagram



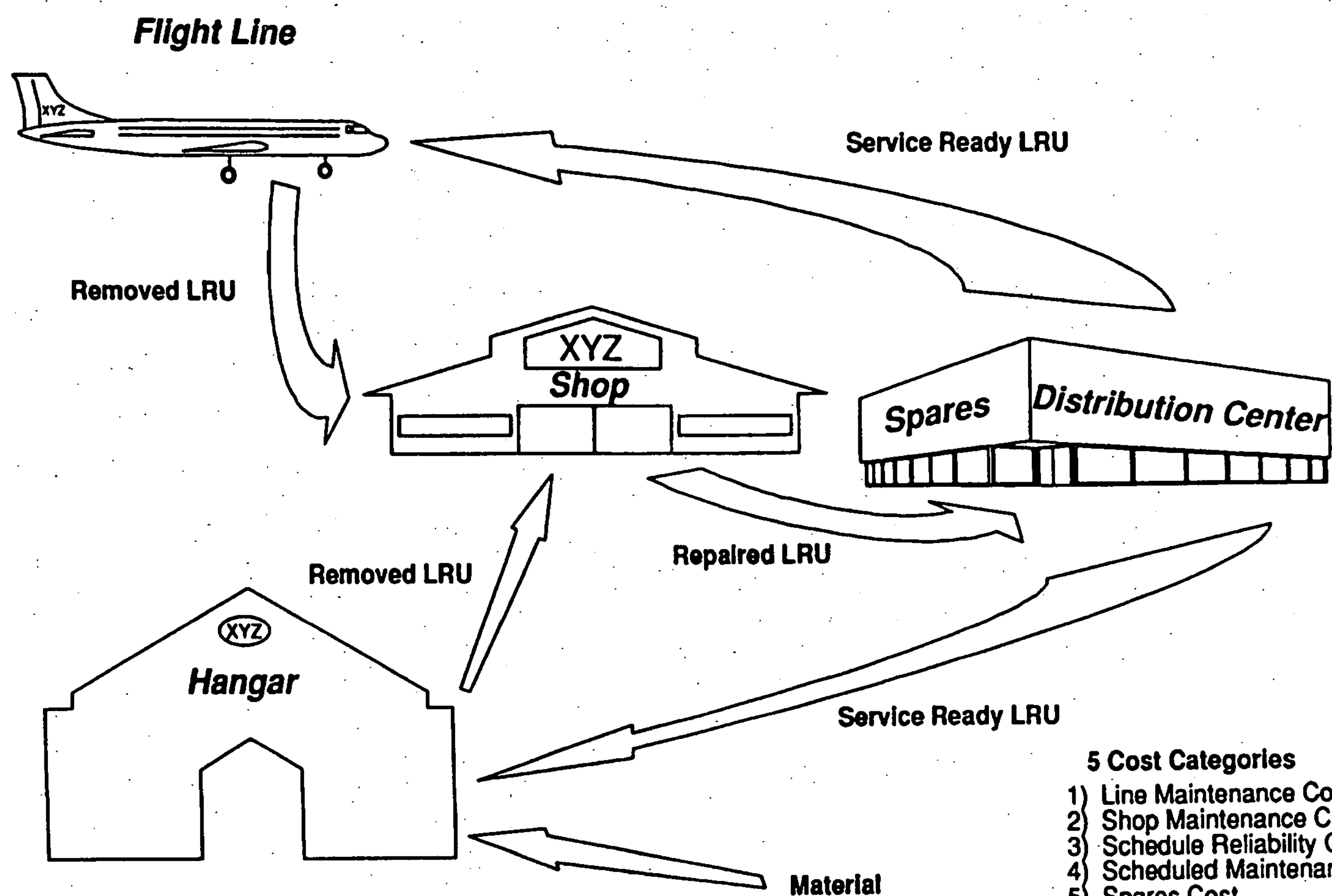
Project Objective

Incorporate ***Dependability Cost*** Estimation Capability For IDG/VFG Into ASSET Electrical Power System Module.

Dependability: *A quantitative assessment of an airplane's ability to meet schedules, require low-cost maintenance, and be easily and quickly restored when a failure occurs.*

5 Elements of Dependability Cost

(Simplified Maintenance View)

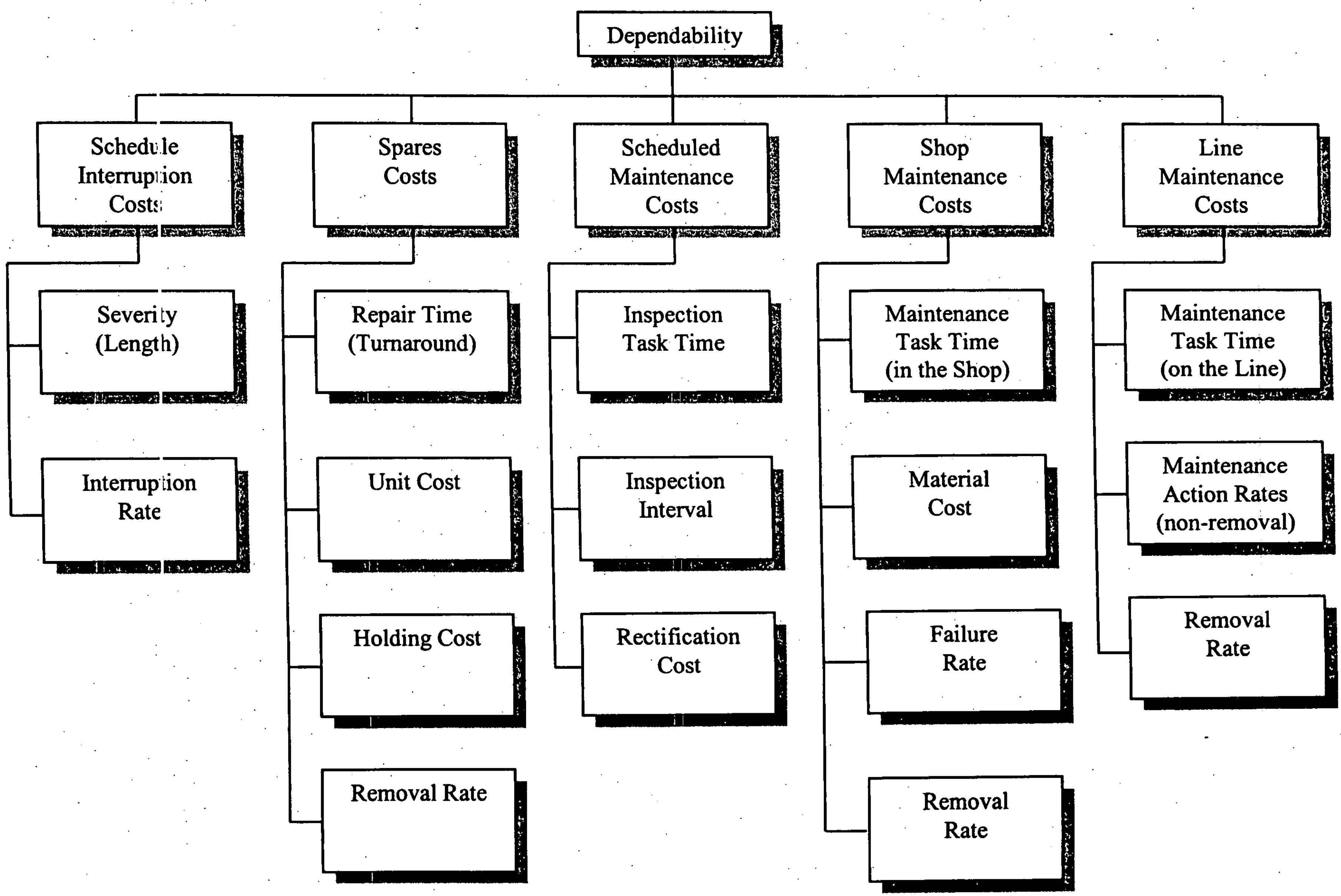


5 Cost Categories

1) Line Maintenance Cost
2) Shop Maintenance Cost
3) Schedule Reliability Cost
4) Scheduled Maintenance Cost
5) Spares Cost

Dependability Cost Element Matrix

(ASSET Electrical Power System)



Customer Cost Impact Analysis

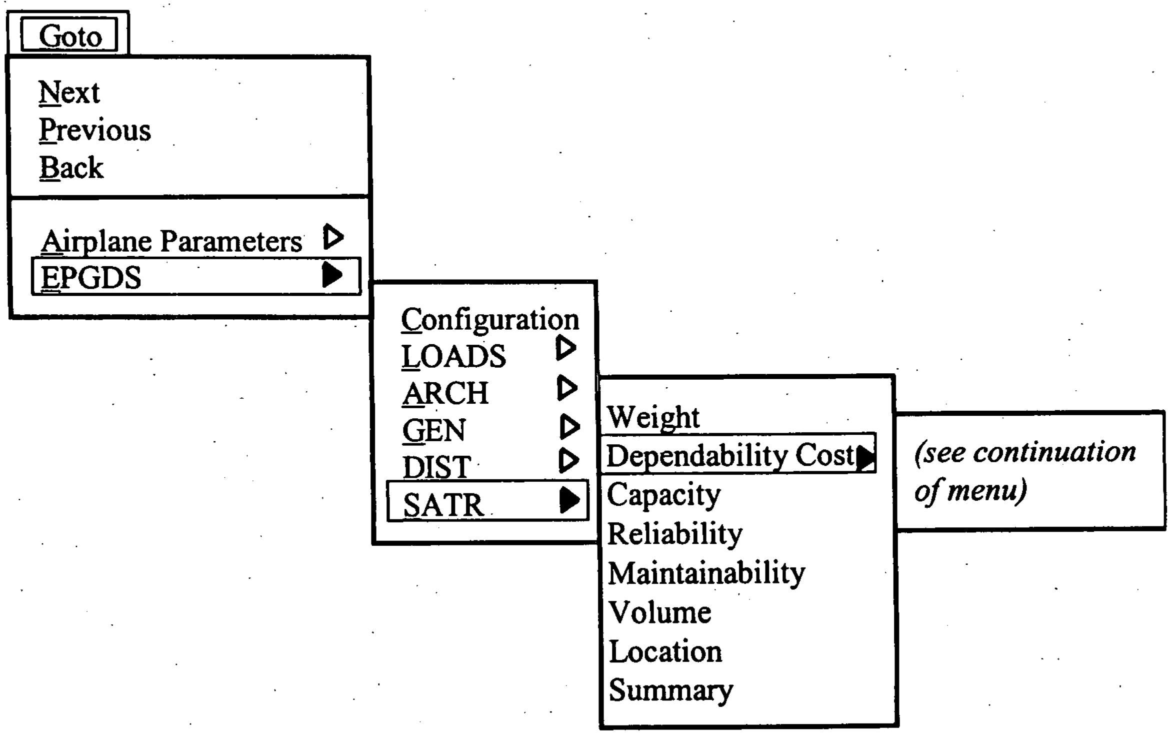
Program:	777	Date:	8/11/99
System ID	IDG/VFG	Life Cycle	20
Study Year	1999	Fleet Size	25
Analyst:	Bob Bond	ATA/SRPC #	0

EXAMPLE

	Cost Impact
Acquisition Costs (Fleet)	
System	$0
System Spares	$0
System Support Equipment	$0
Training	$0
Total Acquis. Costs (Fleet)	$0
Operating Costs (Fleet)	
Fuel Cost	$0
Due to Weight	$0
Due to Energy Rqmnts	$0
Due to Drag	$0
Due to Cooling	$0
Base Fuel	$0
Maintenance Costs	$0
Line Maintenance Labor	$0
Shop Maintenance Labor	$0
Scheduled Maintenance	$0
Shop Material	$0
Delay Costs	$0
Cancellation Costs	$0
Air Turnback Costs	$0
Diversion Costs	$0
Spares Holding Costs	$0
System Insurance Cost	$0
Total Operating Costs (Fleet)	$0
Total Costs (Present Value - Fleet over 20 Years)	$0
Total Acquisition Costs, NPV per Airplane	$0
Total Operating Costs, NPV per Airplane	$0
Airline Cost Impact per Airplane (Present Value over 20 Years)	$0
Total Cost Impact per Airplane per Year (Non Inflated, Non Discounted Cash Flow)	$0

Pull-down Menu for Dependability Cost

Pull-down menu for Dependability Cost:



Dependability Cost Menu (continued)

- Configuration
- LOADS
- ARCH
- GEN
- DIST
- SATR

- Weight
- Dependability Cost
- Capacity
- Reliability
- Maintainability
- Volume
- Location
- Summary

- Common Dependability Cost Inputs
- System Acquisition Costs
- Fuel Costs
- Spares Costs
- Line Maintenance Costs
- Shop Maintenance Costs
- Scheduled Maintenance Costs
- Schedule Interruption Costs
- Schedule Interruption Costs
- Dependability Cost Summary

Sample Input/Output Screens

File Run Goto Report Help

Spares Costs

Cost per Spare Unit (base year)	SpareCost
Spares Holding Factor	SpareFac
Shop Turn-around Time (days)	TurnDays
Main Base Fill Rate	FillRate
Mean Time Between Unscheduled Removals	MTBUR
Mean Time Between Overhauls	MTBO
Number of Spares Required	SpareReq
Initial Spares Acquisition Cost	INI_SPARE_COST
Spares Holding Cost (NPV of Life Cycle Cost)	HOLD_COST
Spares Costs (NPV of Life Cycle Cost)	SPARE_COST_NPV
Spares Costs (per Airplane per Year)	SPARE_COST

ASSET EPGDS Method

Sample Screens (continued)

File Run Goto Report Help

Shop Maintenance Costs

Direct Labor Rate per Hour	DirLabor
Maintenance Labor Burden Factor	BF
Mean Time Between Unscheduled Removals	MTBUR
Mean Time Between Failures	MTBF
Mean Time Between Overhauls	MTBO
Shop Labor Man-Hours per Unconfirmed Failure (Test)	SLaborMHrsTest
Shop Labor Man-Hours per Failure (Test & Repair)	SLaborMHrsRepTest
Shop Labor Man-Hours per Overhaul	OverLab
Shop Materials Cost per Failure (base year)	SMatFail
Shop Materials Cost per Overhaul (base year)	OverMat

Shop Maintenance Cost (NPV of Life Cycle Cost)	SHOP_COST_NPV
Shop Maintenance Cost (per Airplane per Year)	SHOP_COST

ASSET EPGDS Method

Sample Screens (continued)

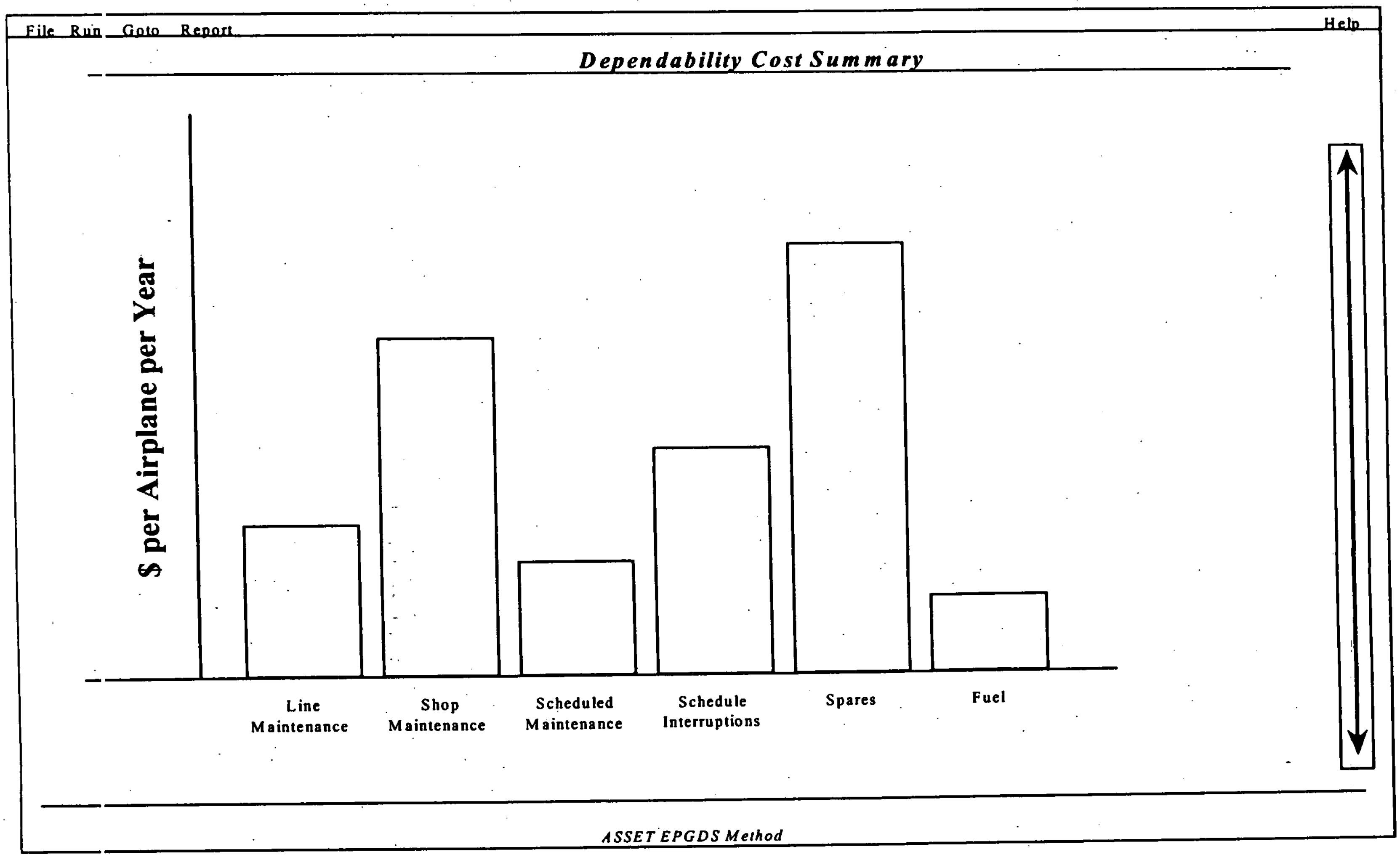
File Run Goto Report Help

Schedule Interruption Costs

Average Delay Cost per Delay Hour	DelayCost
Average Cancellation Cost per Cancellation	CancelCost
Average Air Turnback Cost per Air Turnback	AirTbkCost
Average Diversion Cost per Diversion	DiverCost
Number of Delays per 100 Departures	NumDelays
Average Delay Time (hours)	AveDelayTm
Number of Cancellations per 100 Departures	NumCancels
Number of Air Turnbacks per 100 Departures	NumATbks
Number of Diversions per 100 Departures	NumDivs
Shop Maintenance Cost (NPV of Life Cycle Cost)	SCHED_INT_COST_NPV
Shop Maintenance Cost (per Airplane per Year)	SCHED_INT_COST

ASSET EPGDS Method

Sample Screens (continued)



CDR Agenda

12:30 PM	Introduction	James Lee
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2:10 PM	Power Panels	Glenn Parkan
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2:30 PM	Reliability	Paul Covert
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3:10 PM	Maintainability	Paul Covert
3:20 PM	Dependability Cost	Mahyar Rahbarrad
3:40 PM	Weight Summaries	Bob Bond
3:50 PM	Review Action Items	Reid Wakefield
4:00 PM	Adjourn	

ASSET Electrical Method

Weight Summaries

Bob Bond

ASSET Method Development

[redacted]

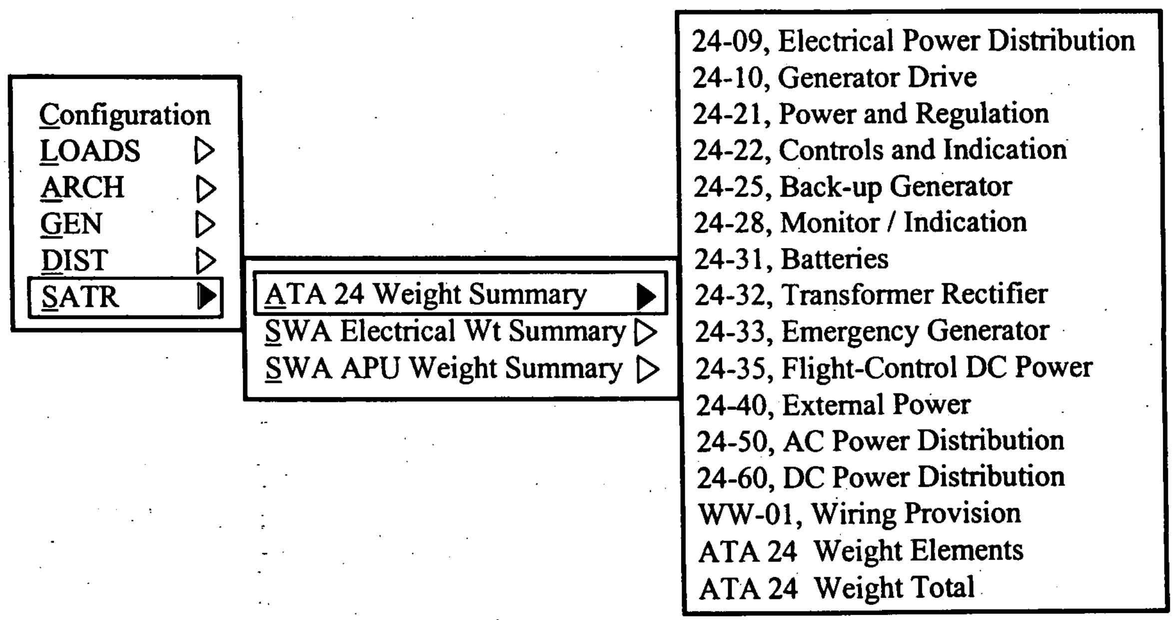
Report Implementation

Air Transport Association (ATA) Chapter 24 is the baseline reporting method

Standard Weight Attributes (SWA's) will be added to SW Functional Spec by 12/23/99

- Function Code 32 will not be implemented

ATA24 Pull-Down Menu
(Example)



ATA 24-21 Screen

File Run Goto Report Help

ATA Chapter 24-21, Power and Regulation

Component Attribute Summary: Comp #	Component Designation	Quantity	Unit Weight	Subtotal Weight
M24001	IDG AC Gen, INBD R	1	156.6 LB	156.6 LB
M24001	IDG AC Gen, INBD L	1	154.6 LB	154.6 LB
M24001	IDG AC Gen, OBD R	1	154.6 LB	154.6 LB
M24001	IDG AC Gen, OBD L	1	154.6 LB	154.6 LB
M24003	APU Generator R	1	67.0 LB	67.0 LB
M24003	APU Generator L	1	67.0 LB	67.0 LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB
...	...	...	... LB	... LB

ASSET EPGDS Method

Standard Weight Attribute's for Electrical

Undistributed
AC System - Control/Monitoring/Indication
AC System - Feeder Wiring
AC System - Generators
Busses/Power - Distribution Wiring
DC System - Control/Monitoring/Indication
DC System - Batteries
DC System - Generators
DC System Feeder Wiring
Undistributed Connectors - Ships Wiring
Undistributed Installation - Ships Wiring

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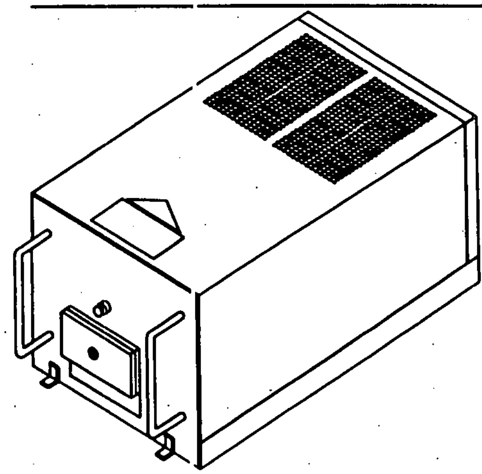
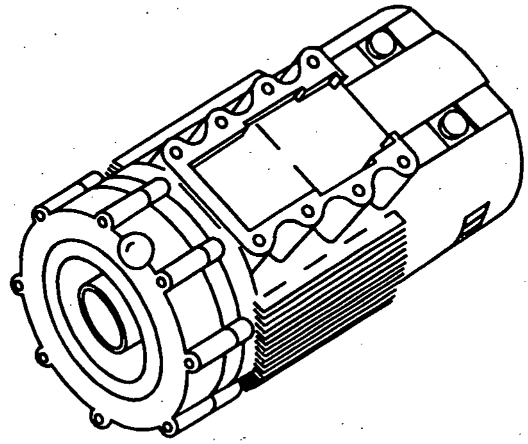
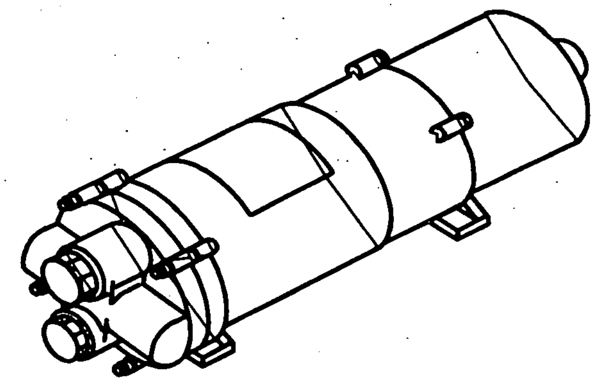
File Run Goto Report Help

Emergency Power Generation







Static Inverter Unit

AC Standby Load	AC_Stdby_load	V-A
Unit Efficiency	SIU_Eff	
Adjusted Load	SIU_Cap	V-A
Static Inverter Unit Weight	SIU_WT	Lb.

Based on 28V DC Input Voltage

Ram Air Turbine (RAT) Generator

RAT Generator	RATG_Req	
RAT Generator Capacity*	RATG_Cap	kVA
RAT Generator Unit Weight	RATG_Wt	Lb.

Hydraulic Motor Generator (HMG)

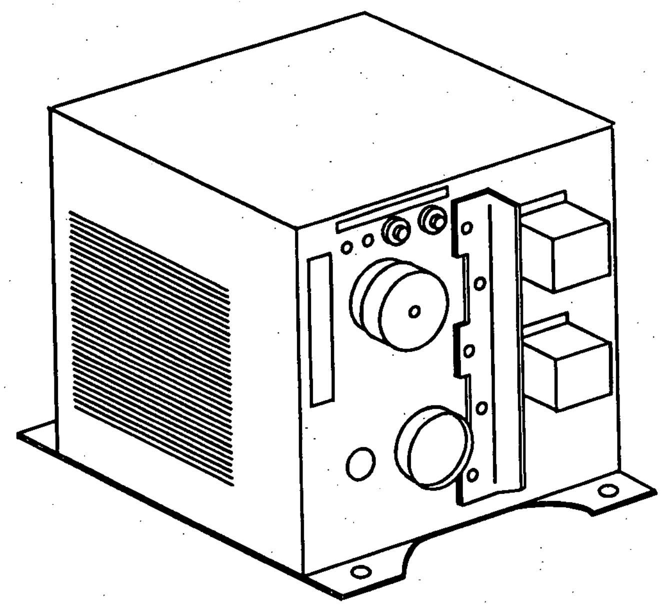
HMG	HMG_Req	
HMG Capacity	HMG_Cap	kVA
HMG Unit Weight	HMG_Wt	Lb.

* Default capacity requirements used for the RAT Generator and Hydraulic Motor Generator based on 2-engine Fly-By-Wire Airplane emergency power requirements

ASSET EPGDS Method

File Run Goto Report Help

Generator Control Units (GCU)



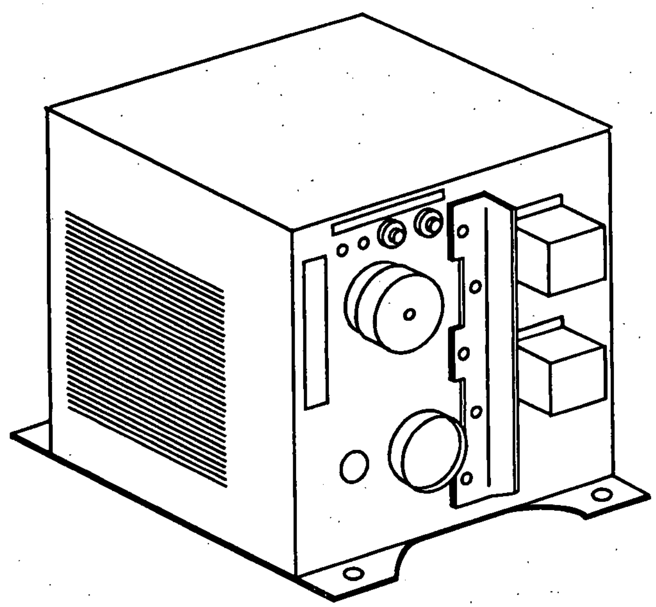
	Main AC Power Generator Control Unit		APU Generator Control Unit		RAT Generator Control Unit	
Unit Size	MainAC_GCU_Size	MCU	APU_GCU_Size	MCU	RAT_GCU_Size	MCU
GCU Wt.	MainAC_GCU_Wt	Lb.	APU_GCU_Wt	Lb.	RAT_GCU_Wt	Lb.

Generator Control Unit Volume is not related to host generator capacity. Default size of 3 MCUs was used due to commonality across models.

ASSET EPGDS Method

File Run Goto Report Help

Generator Control Units (GCU)



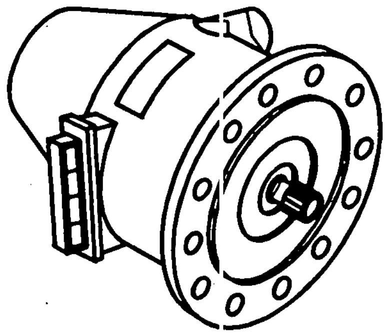
	Main AC Power Generator Control Unit		APU Generator Control Unit		RAT Generator Control Unit	
Unit Size	3	MCU	3	MCU	0	MCU
GCU Wt.	8.9	Lb.	8.9	Lb.	0	Lb.

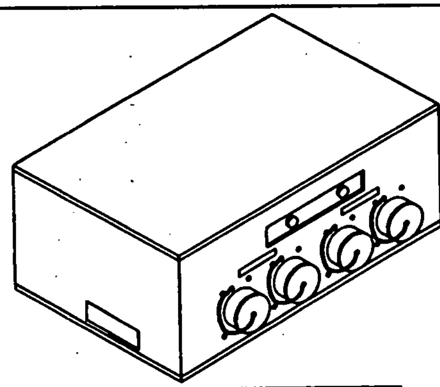
Generator Control Unit Volume is not related to host generator capacity. Default size of 3 MCUs was used due to commonality across models.

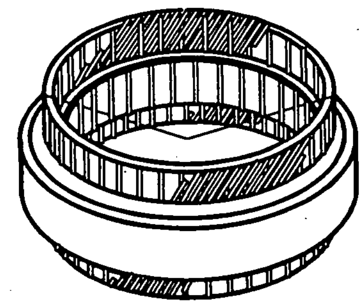
ASSET EPGDS Method

File Run Goto Report Help

Back Up Power Generation





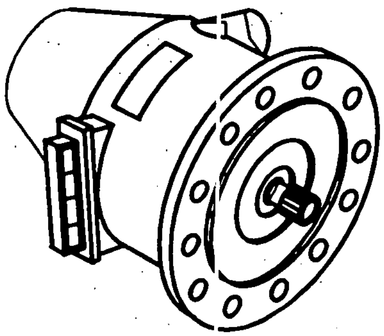


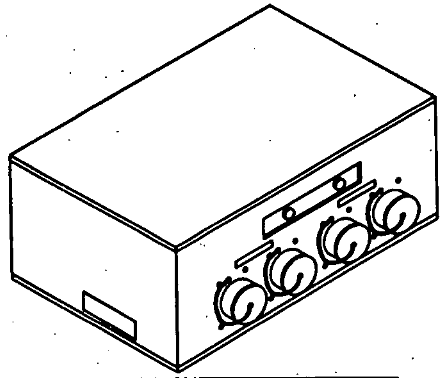
Back Up Generator	Back_Up_ Gen_Type		**Permanent Magnet Generators**	PMG_Req	
Back Up Cooling Method	Back_Up_Cooling_Meth		**No. of PMGs/engine**	PMG_Per_Engine	
Back Up Input Speed	Back_Up_Gen_Inspeed	RPM	**PMG Configuration**	PMG_Config	
Back Up Generator Capacity	Back_Up_Gen_Cap	kVA	**PMG Unit Weight**	PMG_Wt	Lb.
Back Up Generator Unit Weight	Back_Up_Gen_Wt	Lb.			
Back Up VSCF Converter Config.	Back_Up_Conv_Config				
Back Up VSCF Converter Load	Back_Up_Conv_Load	kVA			
Back Up VSCF Converter Weight	Back_Up_Conv_Wt	Lb.			

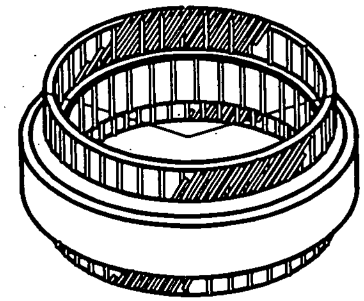
ASSET EPGDS Method

File Run Goto Report Help

Back Up Power Generation







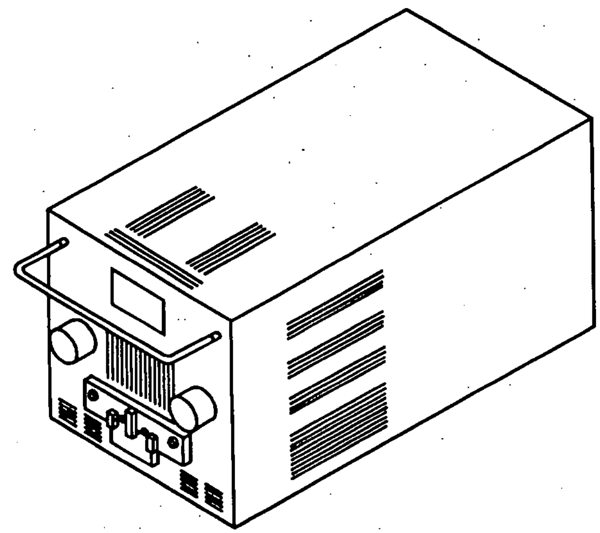
Back Up Generator	VSCF	
Back Up Cooling Method	Oil	
Back Up Input Speed	12000	RPM
Back Up Generator Capacity	25	kVA
Back Up Generator Unit Weight	39.2	Lb.
Back Up VSCF Converter Config.	Stand-Alone	
Back Up VSCF Converter Load	25	kVA
Back Up VSCF Converter Weight	57.8	Lb.

Permanent Magnet Generators	Part of Configuration	
No. of PMGs/engine	2	
PMG Configuration	Integrated w/ Gen.	
PMG Unit Weight	0	Lb.

ASSET EPGDS Method

File Run Goto Report Help

Transformer Rectifier Unit (TRU)



DC Output	TRU_Cap	A
Efficiency	TRU_Eff	
TRU Weight	TRU_Wt	Lb.

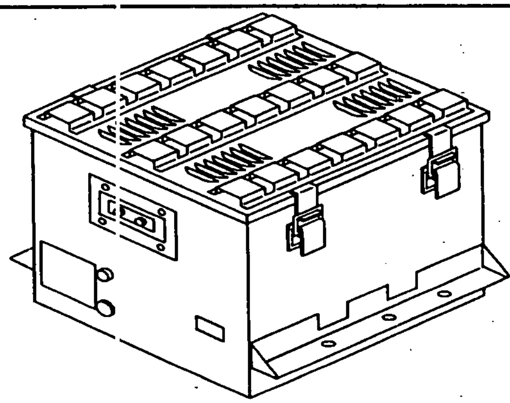
Capacity based on dispatch requirements of 1 TRU being out

28 Volts DC

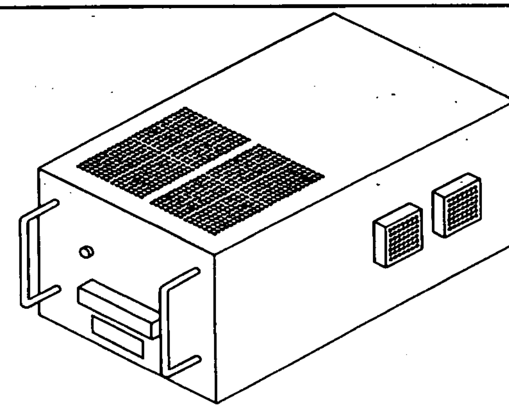
ASSET EPGDS Method

File Run Goto Report Help

Battery & Battery Chargers



Battery



Battery Chargers

Main

Nominal Capacity Main_Batt_Cap Amp-hour @ 1-hour rate

Battery Weight Main_Batt_Wt Lb.

Output Main_Batt_Chgr_Cap Amp

Battery Charger Weight Main_Batt_Chgr_Wt Amp-Hour

Default capacity assumes main battery is sole source for standby power.

APU

Nominal Capacity APU_Batt_Cap Amp-hour @ 1-hour rate

Battery Weight APU_Batt_Wt Lb.

Output APU_Batt_Chgr_Cap Amp-Hour

Battery Charger Weight APU_Batt_Chgr_Wt Amp

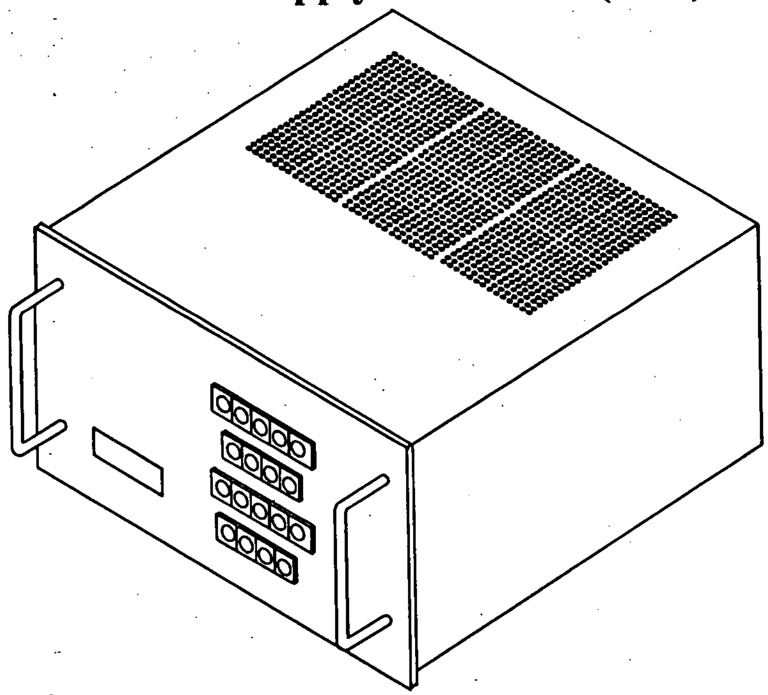
115/230 V AC Input 28 Volts DC Output

ASSET EPGDS Method

File Run Goto Report Help

Flight Control DC Power

Power Supply Assemblies (PSA)



Output Power	PSA_Cap	Watts	**Number of Dedicated Batteries**	No_PSA_Batt
Converter Architecture	PSA_Arch		**Total Dedicated Battery Weight**	Total_PSA_Batt_Wt
Power Supply Assy Weight	PSA_Wt	Lb.		

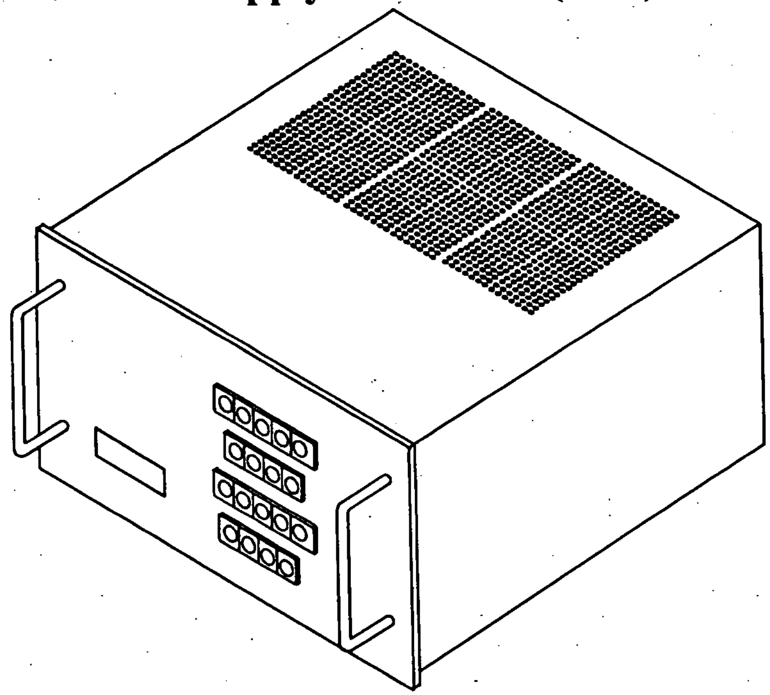
Power supply assemblies applicable only to Fly-By-Wire Airplanes

ASSET EPGDS Method

File Run Goto Report Help

Flight Control DC Power

Power Supply Assemblies (PSA)



Output Power	550	Watts	**Number of Dedicated Batteries**	3	
Converter Architecture	Dual		**Total Dedicated Battery Weight**	45	Lb.
Power Supply Assy Weight	33.6	Lb.			

Power supply assemblies applicable only to Fly-By-Wire Airplanes

ASSET EPGDS Method

Issues still being addressed

- 230V AC Systems

- VF System Components
  - →Motor Controllers
  - →Converters

- Future technology eras

CDR Agenda

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4:00 PM	Adjourn	

ASSET Electrical Method

Main Power Feeders

Bob Bond

ASSET Method Development

[redacted]

Cross-Functional Support

Key to method cycle-time reduction & acceptance as “best practice”

Simplified theory provided by Ed Woods

Ed presented the technical aspects to ET Management at Technical Thrust Review

Objective

Build generator feeder performance analysis method to:

1. Provide simplified impedance calculation
   - Include non-linear frequency effects
   - Include effects of temperature
   - Include effects of altitude and feeder bundle physical arrangement

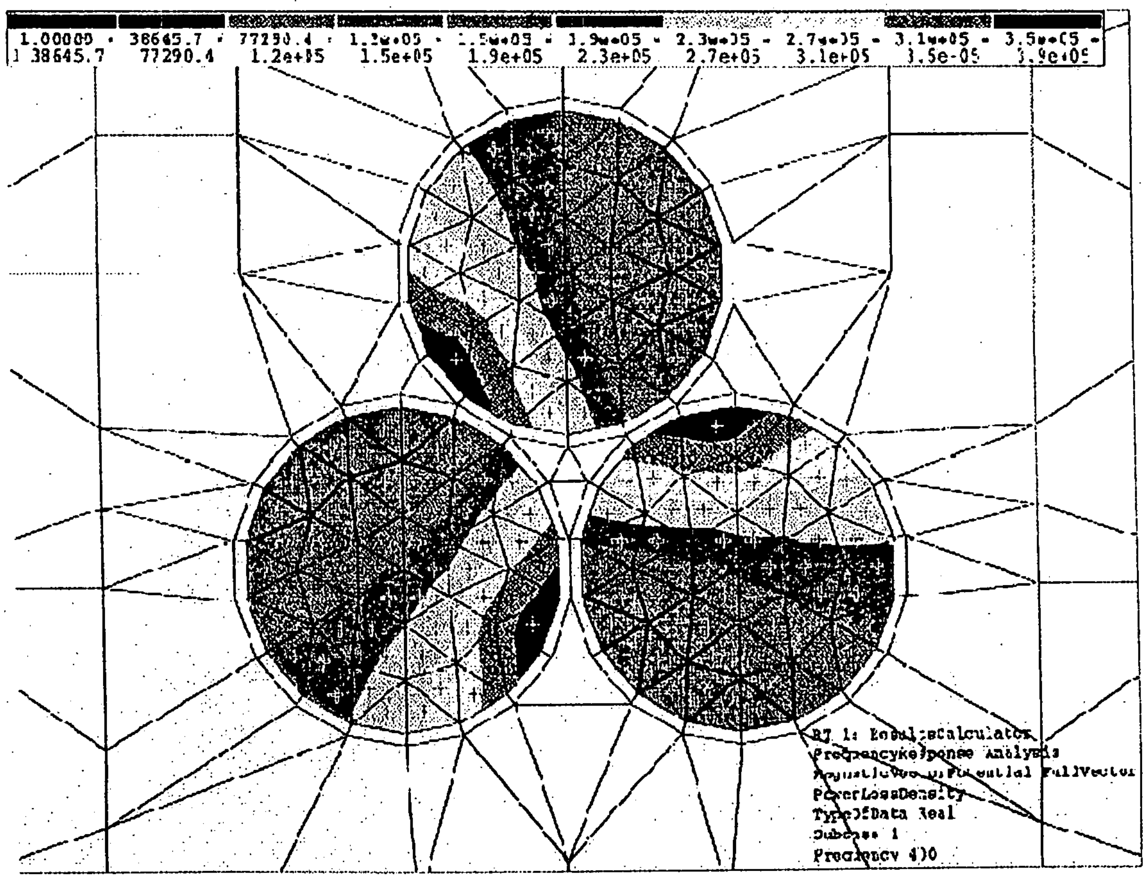
2. Calculate feeder weight and voltage drop

3. Select feeder type based on temperature

Method Process

- Start with Boeing wire specs (BMS 13-60)
  - Weight - lbs/1000 ft
  - DC resistance - ohms/1000 ft
- Use results of magnetic field analysis to determine frequency effects on current distribution within conductor

ASSET Electrical Power System



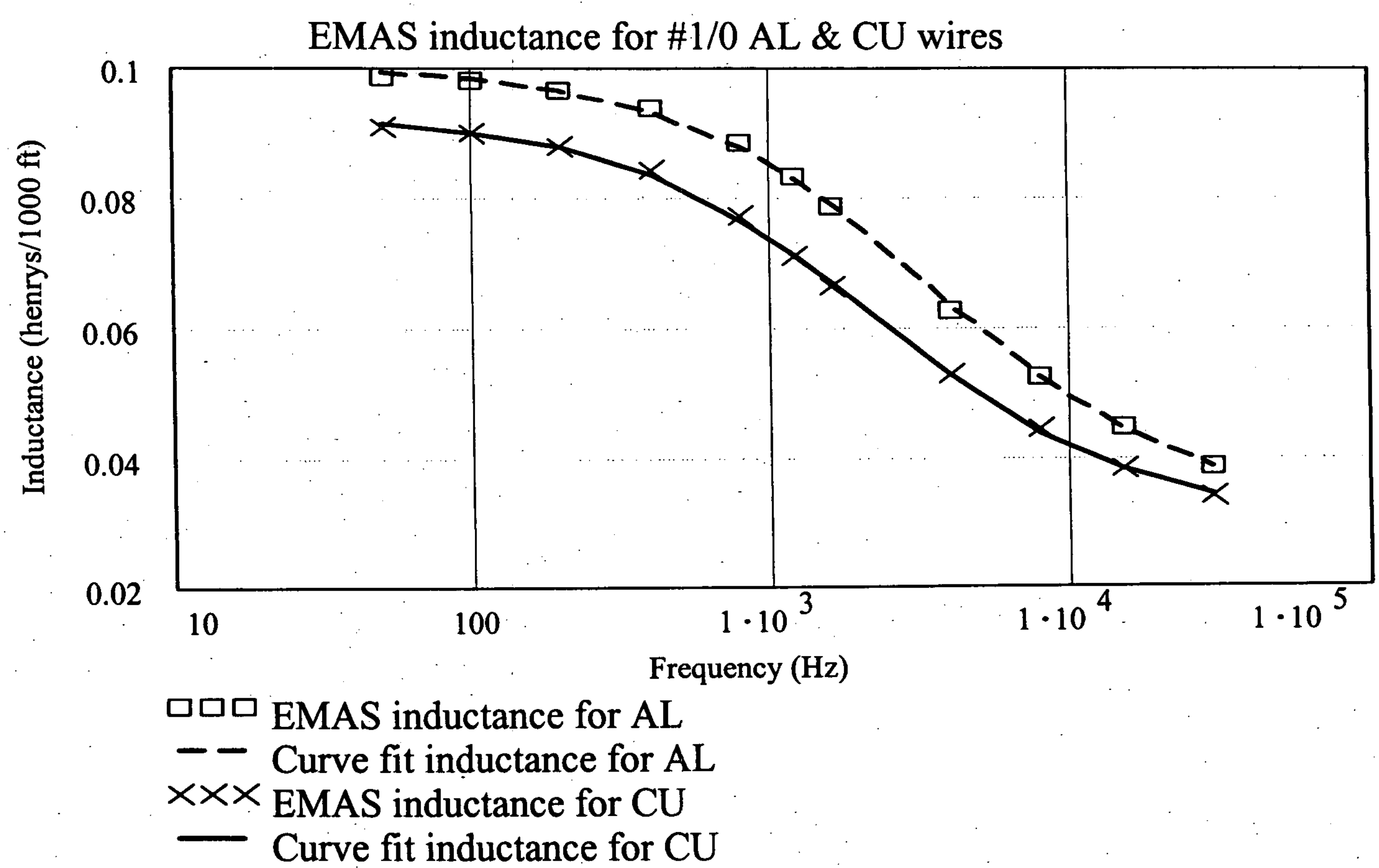
400 Hz Loss Distribution in Three-phase Bundle

Curve Fits for Simplification

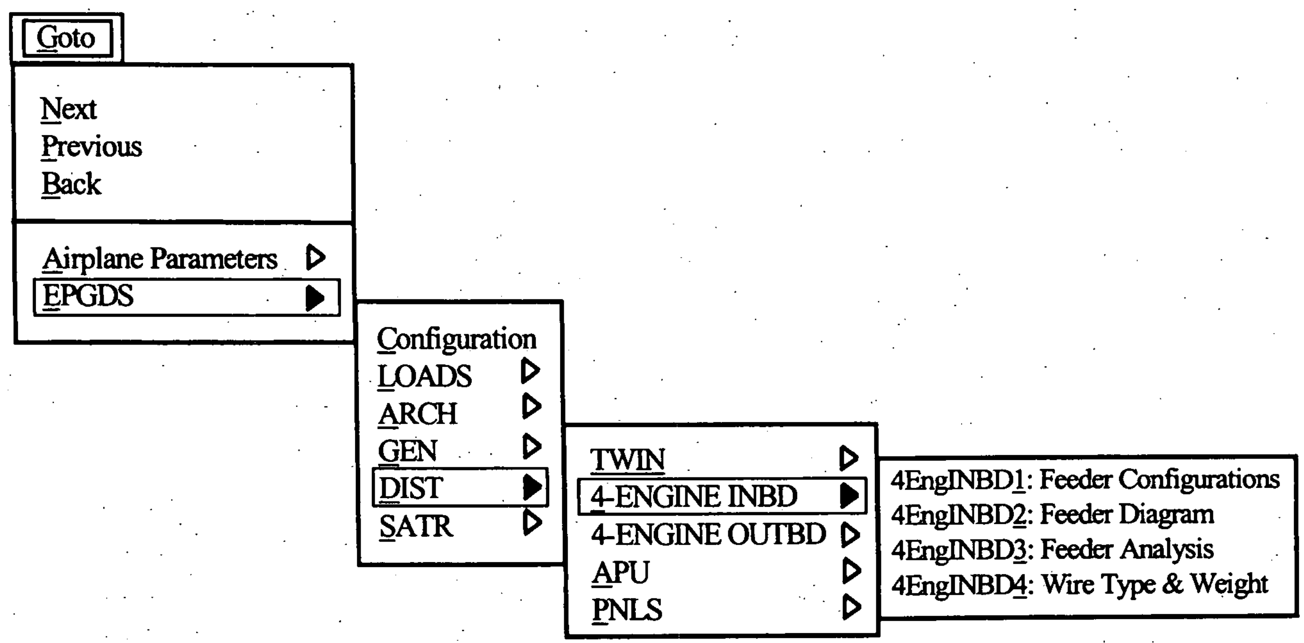
Curve fit data describing resistance and reactance (based on loss and energy from magnetic field analysis)

- $R = Rdc + a_0 * freq^{a_1}$ ohms/1000 ft
- $L = 1/(c_0 * freq + c_1) + c_2$
- $X = 2 * \pi * freq * L$ ohms/1000 ft

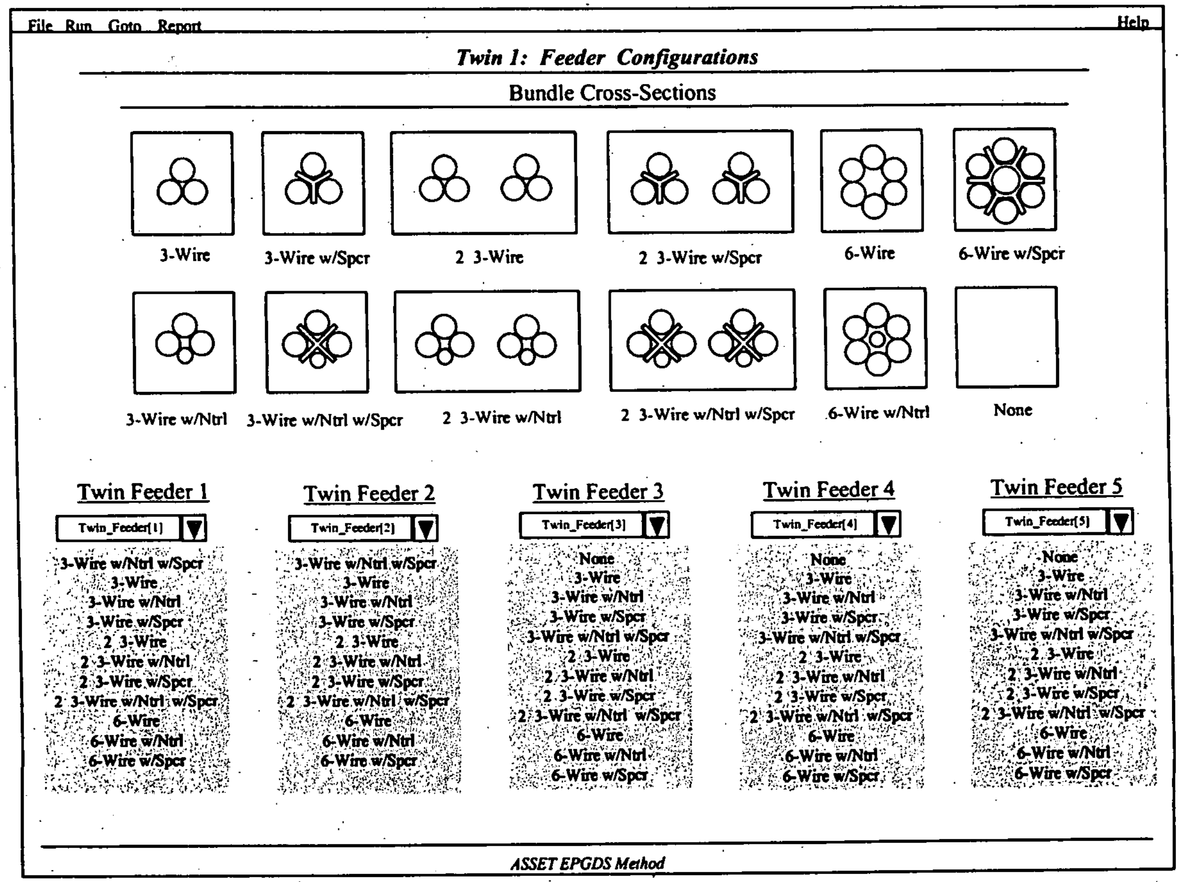
Curve Fit Correlation



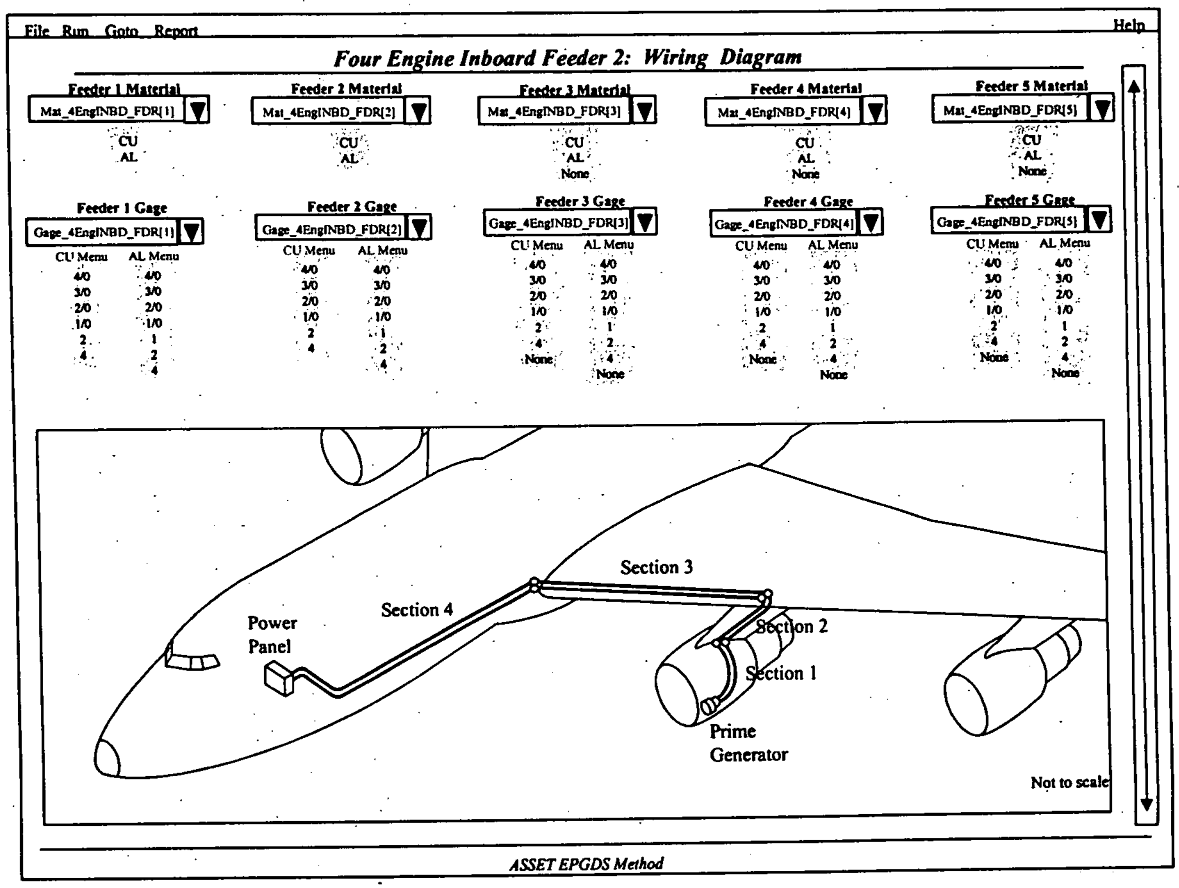
Pull-Down Menu
(Example)



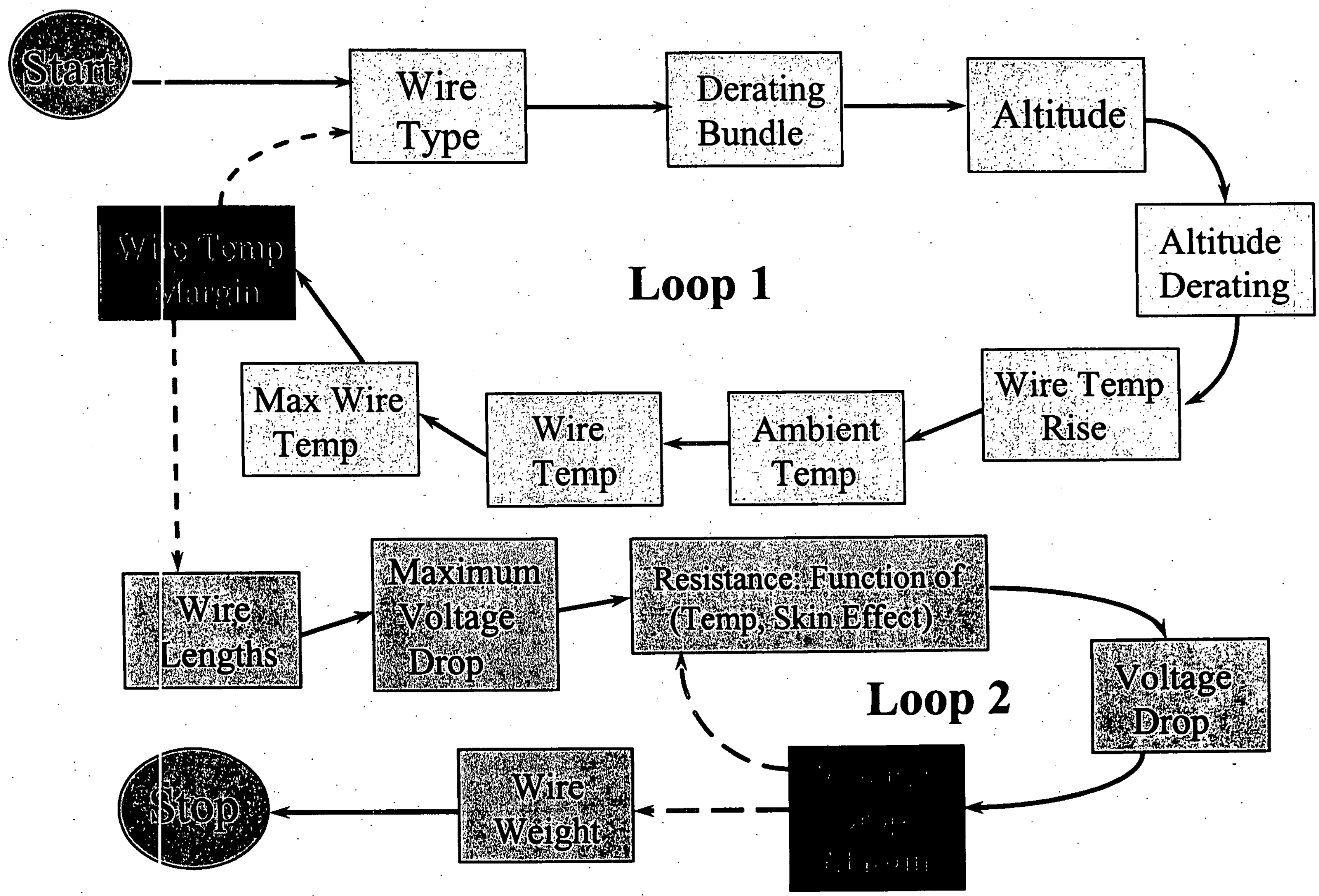
Bundle Selection



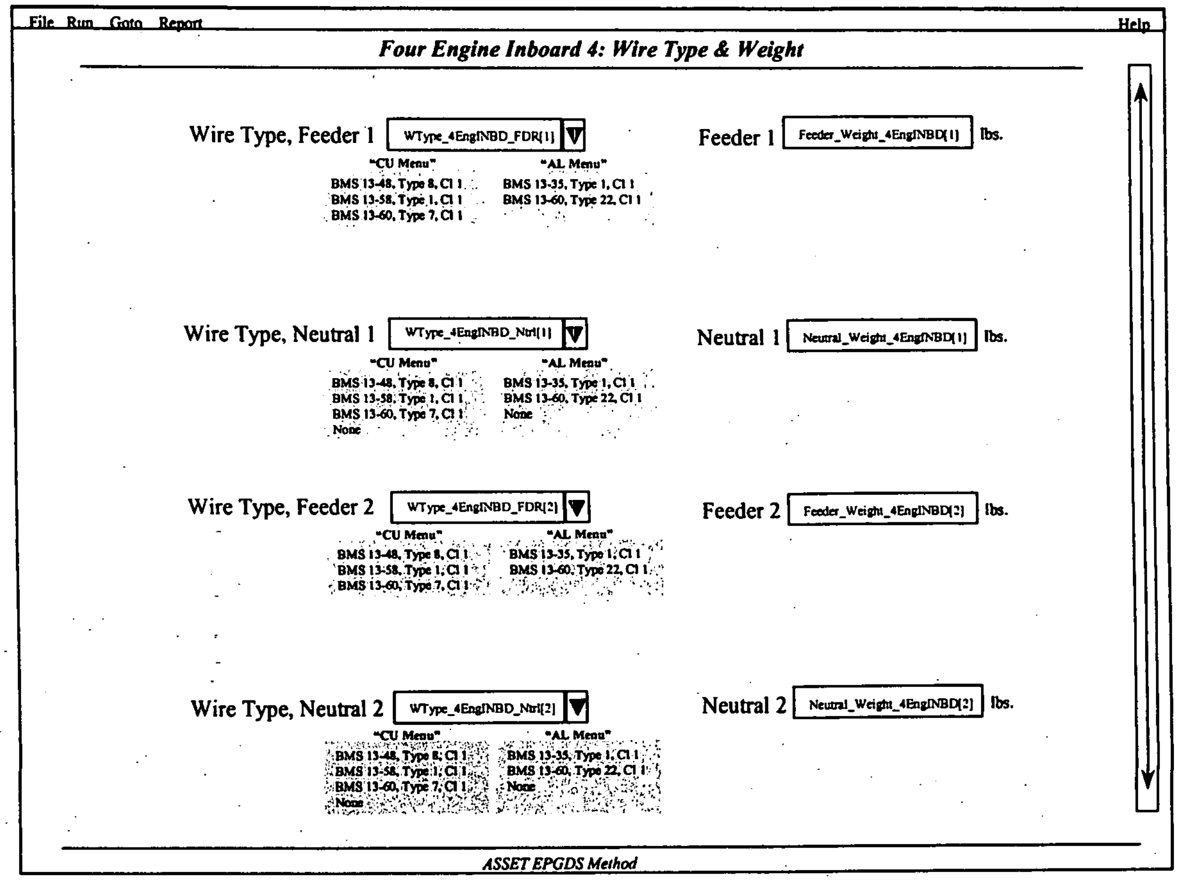
Feeder Diagram



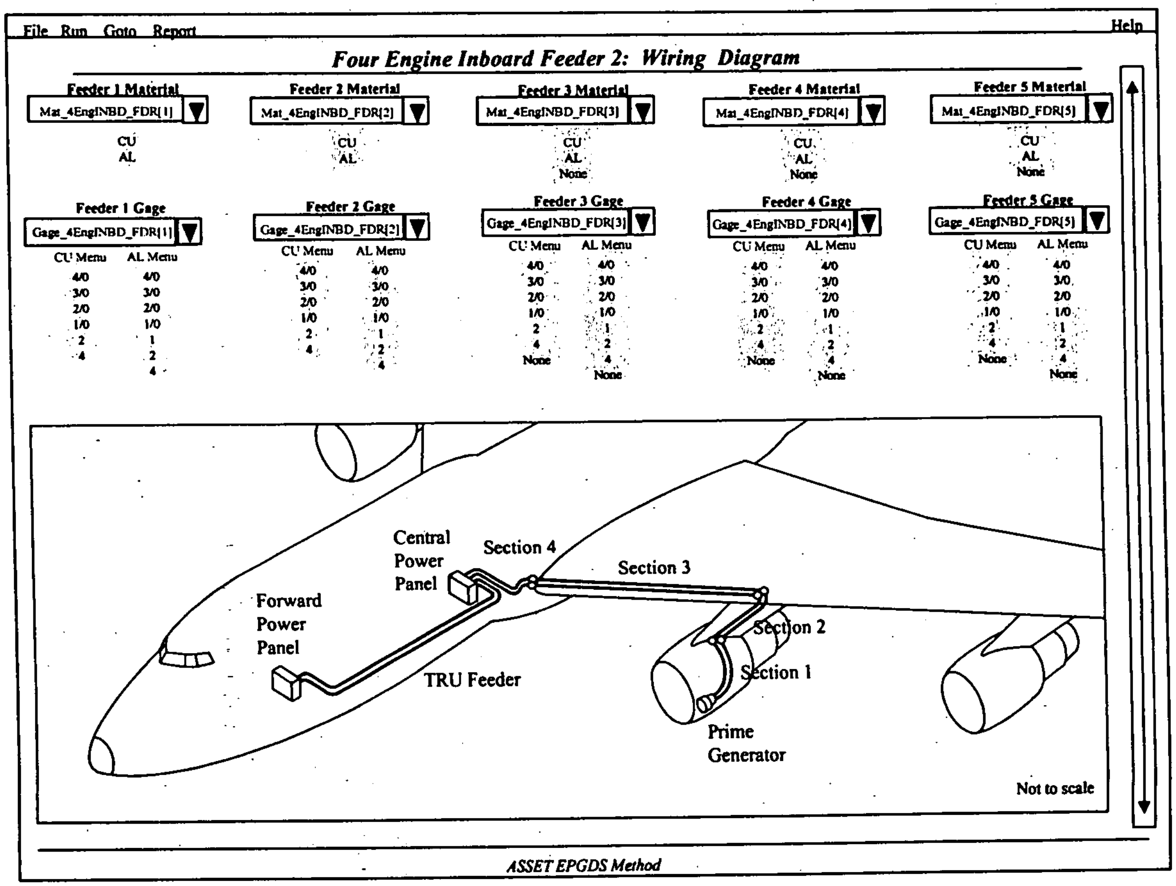
Feeder Wire Selection Process



Feeder Weight Summation



Dual EE Bays



File Run Goto Report
Help
Four Engine Inboard Feeder 2: Wiring Diagram
Feeder 1 Material
Mat_4EngINBD_FDR[1]
CU
AL
Feeder 2 Material
Mat_4EngINBD_FDR[2]
CU
AL
Feeder 3 Material
Mat_4EngINBD_FDR[3]
CU
AL
None
Feeder 4 Material
Mat_4EngINBD_FDR[4]
CU
AL
None
Feeder 5 Material
Mat_4EngINBD_FDR[5]
CU
AL
None
Feeder 1 Gage
Gage_4EngINBD_FDR[1]
CU Menu 4/0 3/0 2/0 1/0 2 4
AL Menu 4/0 3/0 2/0 1/0 1 2 4
Feeder 2 Gage
Gage_4EngINBD_FDR[2]
CU Menu 4/0 3/0 2/0 1/0 2 4
AL Menu 4/0 3/0 2/0 1/0 1 2 4
Feeder 3 Gage
Gage_4EngINBD_FDR[3]
CU Menu 4/0 3/0 2/0 1/0 2 4 None
AL Menu 4/0 3/0 2/0 1/0 1 2 4 None
Feeder 4 Gage
Gage_4EngINBD_FDR[4]
CU Menu 4/0 3/0 2/0 1/0 2 4 None
AL Menu 4/0 3/0 2/0 1/0 1 2 4 None
Feeder 5 Gage
Gage_4EngINBD_FDR[5]
CU Menu 4/0 3/0 2/0 1/0 2 4 None
AL Menu 4/0 3/0 2/0 1/0 1 2 4 None
Central Power Panel
Section 4
Section 3
Forward Power Panel
Section 2
Section 1
TRU Feeder
Prime Generator
Not to scale
ASSET EPGDS Method

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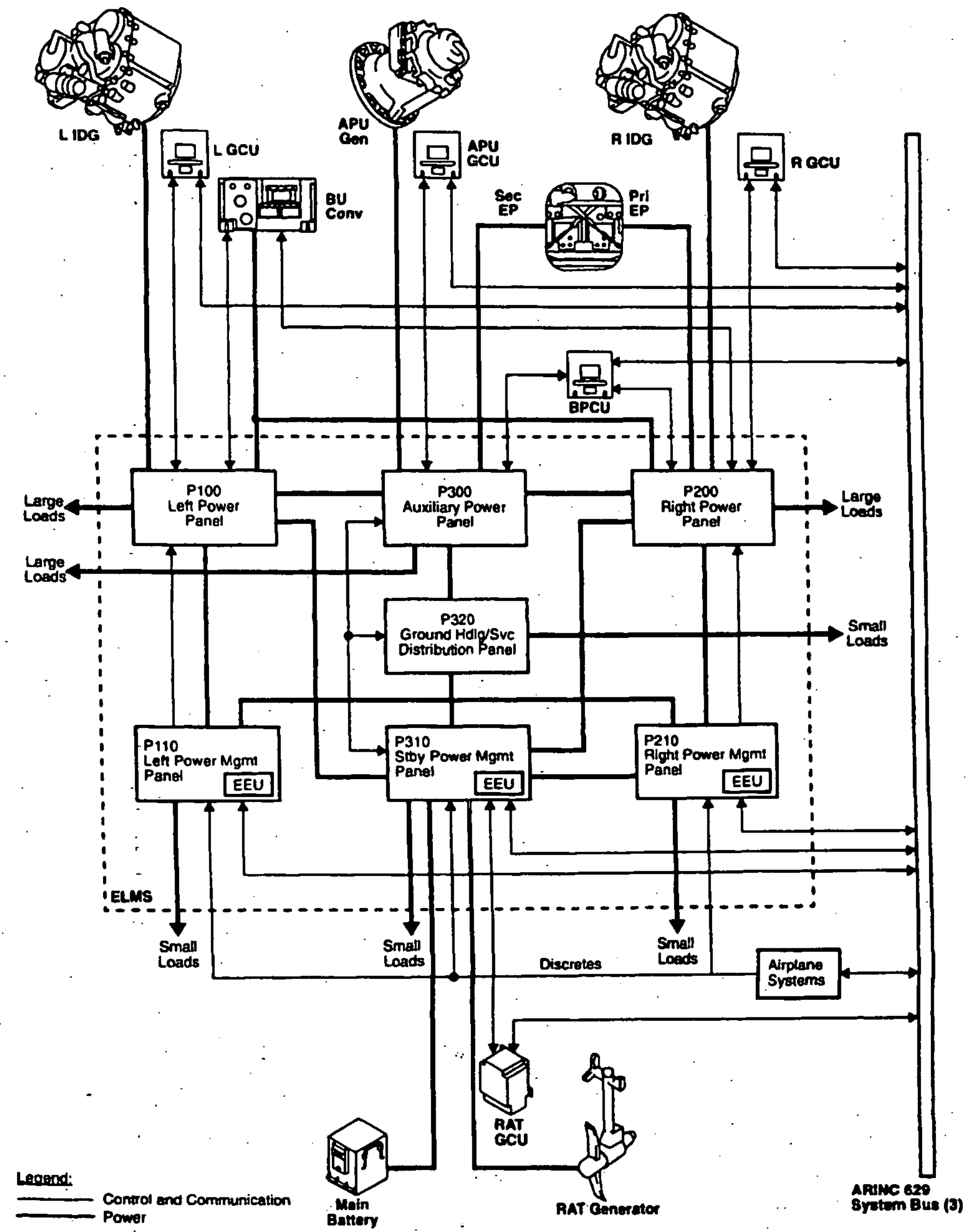
ASSET Electrical Method
Distribution Panels

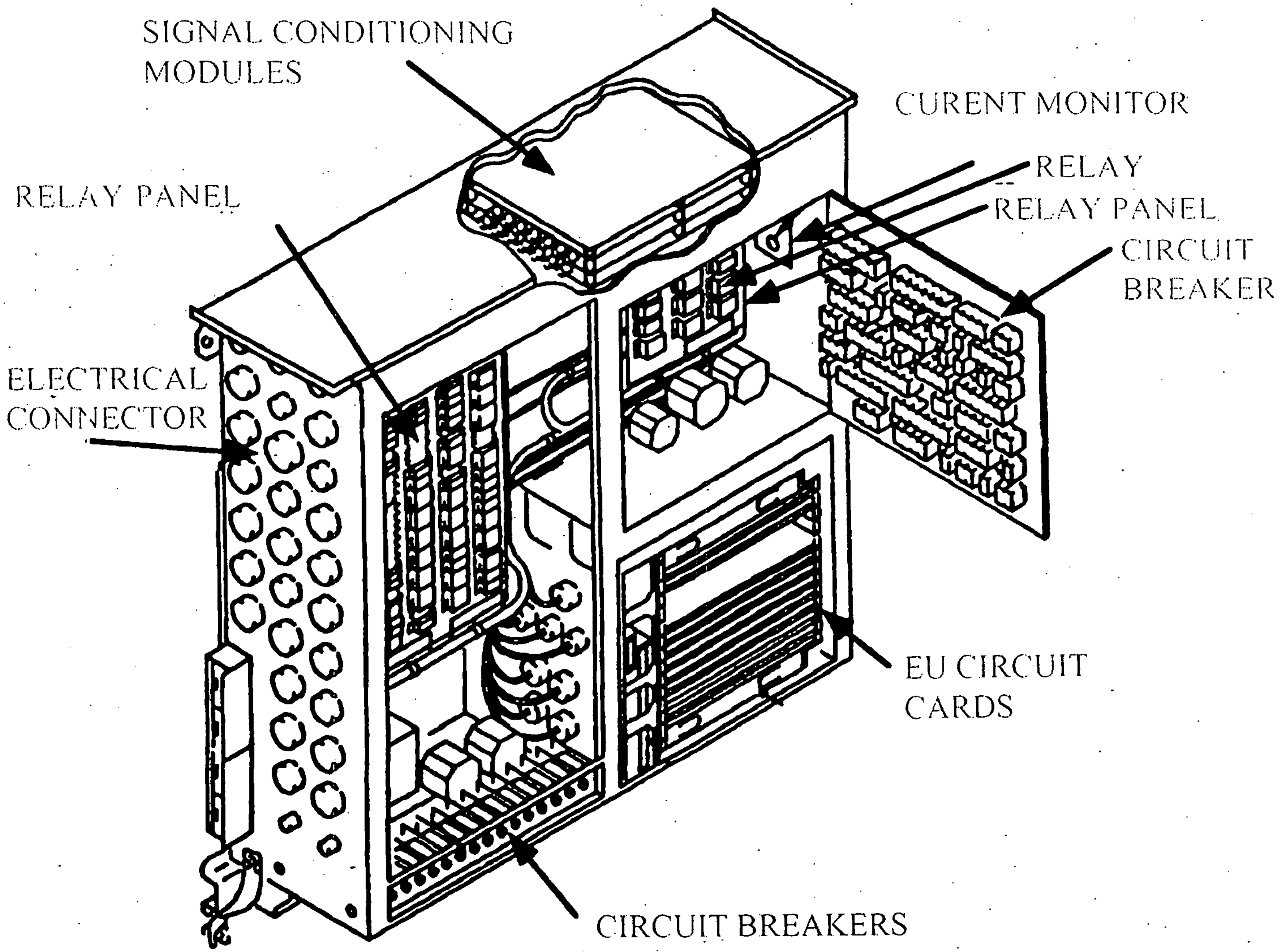
Glenn Parkan
Weight Engineering

777 Electrical Power



Electrical Power System Control

Typical ELMS Power Management Panel



Distribution Panels

Weight Includes:

-- Primary Panels

-- Secondary Panels

Weight estimate is based on a Statistical Regression of 777 Technology Configurations

Option for advanced technology

-- Backplane Technology

-- ELMS Technology

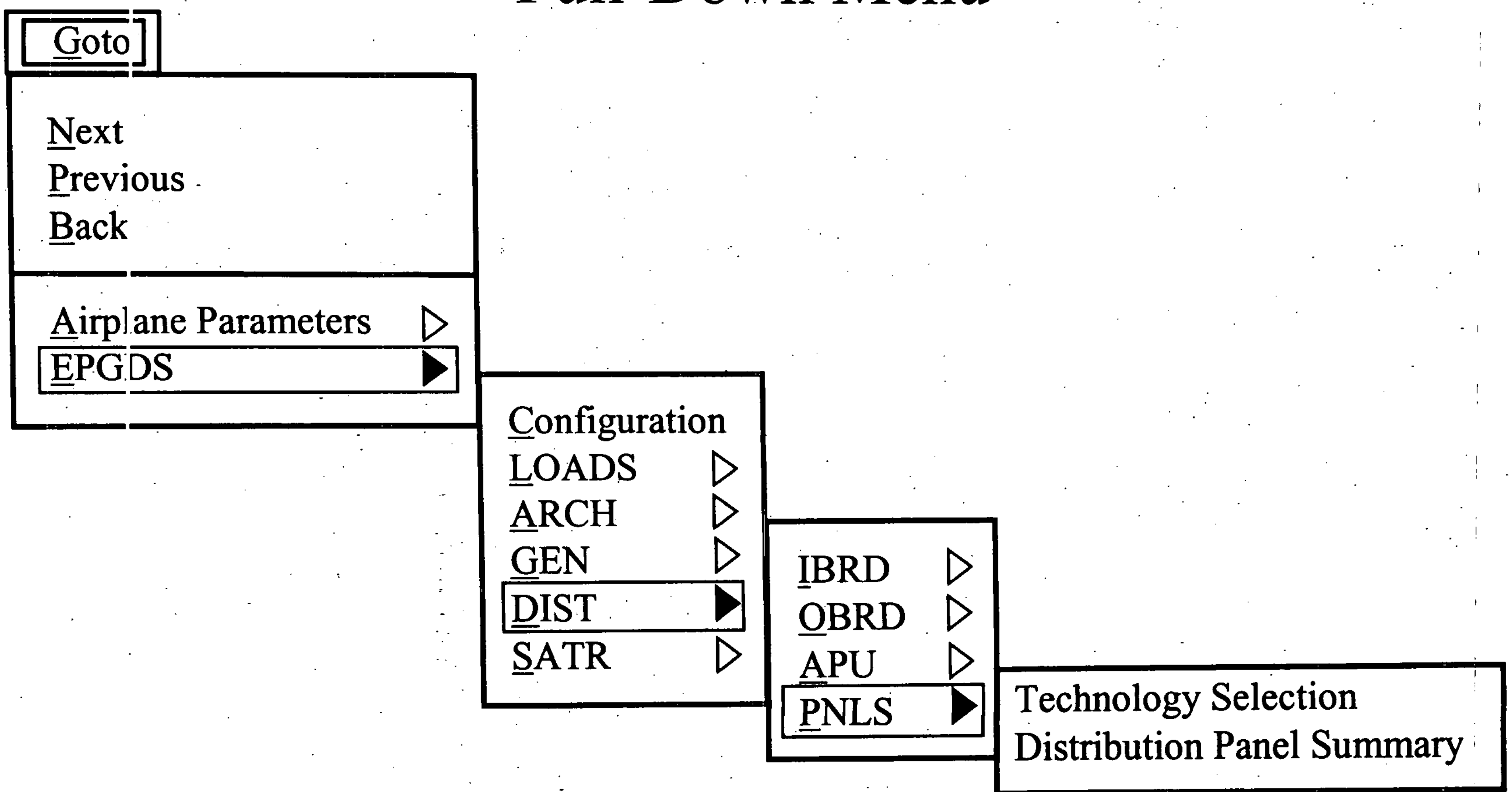
-- Other Advanced Technology

- Estimates the volume of each panel based on weight ratio

Location for each panel based on the selection of one of the four airplane types

Distribution Panel

Pull-Down Menu



File Run Goto Report Help

ATA Chapter 24-09, Electrical Power Distribution

Component Attribute Summary: Comp #	Component Designation	Quantity	Unit Weight		Subtotal Weight	
P100	Left Primary Power Panel	1	94.4	lb	94.4	lb
P110	Left Mgmt Power Panel	1	163.1	lb	163.1	lb
P200	Right Primary Power Pan	1	112.6	lb	112.6	lb
P210	Right Mgmt Power Panel	1	160.2	lb	160.2	lb
P300	Auxiliary Power Panel	1	48.3	lb	48.3	lb
P310	Stby Power Mgmt Panel	1	155.4	lb	155.4	lb
P320	Ground Hdlg/Svc Distrib	1	38.5	lb	38.5	lb
CN51[....]	CD51[....]	Q51[....]	UW51[....]	lb	SW51[....]	lb
CN51[18]	CD51[18]	Q51[18]	UW51[18]	lb	SW51[18]	lb
CN51[19]	CD51[19]	Q51[19]	UW51[19]	lb	SW51[19]	lb
CN51[20]	CD51[20]	Q51[20]	UW51[20]	lb	SW51[20]	lb

ASSET EPGDS Method

File Run Goto Report Help

ATA Chapter 24-09, Electrical Power Distribution

Volume (ft^3)	Unit Volume (lb/ft^3)	B.S. (in.)	Location B.L. (in.)	W.L. (in.)
4.3	22.0	Q51[01] in.	UW51[01] in.	SW51[01] in.
7.4	22.0	Q51[02] in.	UW51[02] in.	SW51[02] in.
5.1	22.0	Q51[03] in.	UW51[03] in.	SW51[03] in.
7.3	22.0	Q51[....] in.	UW51[....] in.	SW51[....] in.
2.2	22.0	Q51[....] in.	UW51[....] in.	SW51[...] in.
7.1	22.0	Q51[....] in.	UW51[....] in.	SW51[....] in.
1.8	22.0	Q51[....] in.	UW51[....] in.	SW51[....] in.
CN51[....]	CD51[....]	Q51[....] in.	UW51[....] in.	SW51[....] in.
CN51[18]	CD51[18]	Q51[18] in.	UW51[18] in.	SW51[18] in.
CN51[19]	CD51[19]	Q51[19] in.	UW51[19] in.	SW51[19] in.
CN51[20]	CD51[20]	Q51[20] in.	UW51[20] in.	SW51[20] in.

ASSET EPGDS Method

Technology Selection

Technology Factors:

Backplane Technology	T1	.6 to 1
ELMS Technology	T2	?
Other Advanced Technology	T3	1.00

1. Twin and 4-Engine, Fly-by-Wire
   Weight = 330 Ln (kVA) - 1000 (1/T1)(1/T2)(1/T3)
2. 4-Engine, Non-Fly-by-Wire
   Weight = 330 Ln (kVA) - 830 (1/T1)(1/T2)(1/T3)
3. Twin, Non-Fly-by-Wire
   Weight = 330 Ln (kVA) - 1400 (1/T1)(1/T2)(1/T3)

CDR Agenda

12:30 PM	Introduction	James Lee
12:45 PM	Architecture	George Gregorios
1:05 PM	Loads	George Gregorios
1:25 PM	Generation	Ken Perez
1:50 PM	Main Power Feeders	Bob Bond
2:10 PM	Power Panels	Glenn Parkan
2:20 PM	Break	
2:30 PM	Reliability	Paul Covert
2:50 PM	IRAP Interface	Dave Twigg
3:10 PM	Maintainability	Paul Covert
3:20 PM	Dependability Cost	Mahyar Rahbarrad
3:40 PM	Weight Summaries	Bob Bond
3:50 PM	Review Action Items	Reid Wakefield
4:00 PM	Adjourn	

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